

Development of a Contextual Didactical Design in Measurement Learning Based on Social Constructivism Theory

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ABSTRACT:

This study aims to develop a Contextual Didactical Design for Measurement Learning Based on Social Constructivism Theory that is valid, practical, and effective in overcoming students' learning obstacles. This study employed a Sequential Exploratory approach, consisting of a qualitative phase using the Didactical Design Research (DDR) method and a quantitative phase using a Quasi-Experimental method with a Nonequivalent Control Group Design. The development stages included needs analysis, identification of learning obstacles, formulation of Design Requirements, development of a Hypothetical Learning Trajectory (HLT), prediction of students' responses, development of Didactical Pedagogical Anticipation (ADP), prototype development, validation, implementation, metapedadidactic analysis, Actual Learning Trajectory (ALT) analysis, and retrospective analysis. The results showed that the developed didactical design was able to overcome various students' learning obstacles in measurement topics, including understanding units, using measuring instruments, perimeter, area, volume, capacity, scale, and applying concepts in authentic problems. The implementation of the design through five learning phases, namely problem contextualization, exploration and social discourse, collaboration and scaffolding, construction of measurement concepts, and application and reflection, enhanced students' involvement in the process of knowledge construction. The developed design demonstrated good practicality and effectiveness, as indicated by students' activity level of 90%, students' responses of 86%, an average learning outcome score of 80.45, classical mastery achievement of 82%, and an N-Gain score of 0.78, categorized as high. Therefore, the Contextual Didactical Design Based on Social Constructivism Theory can serve as an evidence-based, adaptive, and responsive alternative instructional design for measurement learning that addresses students' learning needs.

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Keywords: Contextual Didactical Design, Didactical Design Research, Social Constructivism, Learning Obstacles, Measurement Learning.

Introduction

The development of the 21st century has brought fundamental changes in various aspects of life, including technology, economy, society, and culture. Digital transformation through the Industrial Revolution 4.0 and the emergence of the Society 5.0 concept have changed the way humans work, communicate, and acquire knowledge. These conditions have significant implications for education because the learning process can no longer be directed merely toward information acquisition, but must develop critical thinking skills, creativity, collaboration, reflection, and problem-solving abilities. Voskoglou (2019) explains that problem-solving ability is one of the essential competencies in mathematics education because it enables students to deal with complex and dynamically changing problems. In line with this perspective, OECD (2023) defines mathematical literacy as an individual's ability to formulate, apply, and interpret mathematics in various real-life contexts. Therefore, mathematics learning needs to shift from teacher-centered approaches toward learning environments that provide opportunities for students to construct knowledge through experience, interaction, reasoning, and reflection.

Mathematics in education is not merely viewed as a collection of concepts, formulas, and computational procedures, but as a discipline that plays an important role in developing logical, systematic, and analytical thinking abilities, as well as understanding quantitative and spatial relationships. NCTM (2020) emphasizes that quality mathematics learning should provide opportunities for students to understand concepts, use various representations, construct arguments, and apply mathematics in meaningful situations. This perspective indicates that the success of mathematics learning cannot be measured only by students' ability to solve routine problems, but also by their ability to understand the reasoning behind procedures,

select appropriate strategies, and transfer concepts to various new problems. Therefore, mathematics learning should be designed so that students experience the process of concept formation rather than merely receiving the final outcomes of mathematical concepts.

One of the mathematics topics that has a strong connection with students' daily experiences is measurement. At the junior high school level (Phase D), measurement includes understanding quantities, units, measuring instruments, estimation, accuracy, perimeter, area, volume, capacity, and scale. The characteristics of this topic indicate that measurement is not only related to computational skills but also involves activities of comparing objects, determining measurements, selecting measurement strategies, and making decisions based on observation results. Van de Walle et al. (2023) explain that effective measurement learning requires direct experiences so that students can understand the relationship between concrete activities and mathematical representations. Therefore, measurement learning should provide opportunities for students to interact with real objects, use measuring instruments, perform estimations, discuss strategies, and connect these experiences with formal mathematical concepts.

Measurement concepts have hierarchical relationships, meaning that understanding one concept becomes the foundation for understanding other concepts. Understanding length becomes the basis for understanding perimeter and area, while understanding area is related to the development of volume concepts. Furthermore, the ability to perform unit conversions, understand capacity, accuracy, and scale requires students to connect concepts, procedures, representations, and contexts simultaneously. Dasari (2024) explains that measurement learning that is overly abstract and does not provide contextual experiences may cause students to experience misconceptions and develop fragmented understanding. Therefore,

measurement learning requires instructional designs that allow students to obtain concrete experiences before progressing toward symbolic and formal understanding.

Although mathematics learning is ideally directed toward conceptual understanding and application in various contexts, classroom practices still often demonstrate the dominance of procedural approaches. Students are frequently directed to memorize formulas, follow example solutions, and complete exercises without sufficient opportunities to explore the meaning of concepts. Voskoglou (2019) explains that mathematics learning that excessively emphasizes procedures may limit the development of flexible problem-solving abilities because students may be able to follow certain algorithms without understanding the reasons behind the procedures. This condition indicates the need for learning designs that can bridge formal mathematical concepts with students' thinking experiences.

Mathematical understanding does not develop solely through individual activities but also through social interaction processes. Vygotsky (1978) explains that students' cognitive development is influenced by social interaction and mediation processes through language, symbols, and culture. The concept of the Zone of Proximal Development (ZPD) indicates that students can achieve higher levels of competence through assistance from more capable individuals. In mathematics learning, this principle is manifested through discussion activities, collaboration, scaffolding, peer scaffolding, and fading. Therefore, learning should be designed as a process of knowledge construction that involves the relationship between individual experiences and social support.

The perspective of social constructivism in mathematics learning places interaction, communication, and social practices as essential components in the process of knowledge construction. Students do not merely receive mathematical concepts passively but construct understanding through expressing ideas, testing

strategies, providing arguments, and negotiating meanings within the learning environment. Jaworski (2024) explains that mathematical knowledge develops through social practices, discourse, argumentation, and collective reflection, enabling students to build deeper understanding. This perspective indicates that mathematics classrooms should be positioned as learning communities that provide opportunities for students to interact and develop understanding through collaborative activities.

In social constructivist-based learning, the role of teachers shifts from information providers to designers of learning experiences and facilitators of knowledge construction processes. Teachers are responsible for creating didactical situations that enable students to participate actively, develop thinking strategies, and receive appropriate assistance according to their learning needs. Rytälä (2021) explains that mathematics learning cannot be separated from social and cultural contexts because mathematical meanings are constructed through communication activities and interactions within learning communities. Therefore, teachers need to design learning environments that connect mathematical concepts with students' experiences and encourage productive mathematical discourse.

The implementation of social constructivist principles in mathematics learning requires an operational learning design so that theoretical concepts can be applied effectively in classrooms. Learning oriented toward dialogue, collaboration, and reflection requires systematic activity management because teachers need to anticipate various possible student responses during the learning process. Saleem (2021) explains that social constructivist-based learning requires an environment that supports interaction, cooperation, and reflection so that students can actively construct understanding. Furthermore, Tamur and Juandi (2020) through a meta-analysis study demonstrated that constructivist approaches have a positive influence on students' mathematical thinking and problem-solving abilities. These findings indicate that social constructivism has strong potential in

mathematics learning; however, it requires a design that can translate theoretical principles into structured instructional practices.

Although it has strong potential, implementing social constructivist learning in practice is not always easy. Several challenges, such as limited instructional time, curriculum demands, and habitual use of expository teaching approaches, may cause teachers to return to teacher-centered instructional practices. Naidoo and Mabaso (2023) indicate that curriculum pressure and classroom constraints can hinder the optimal implementation of constructivist approaches. In addition, Saleem et al. (2021) explain that managing group discussions, ensuring equal student participation, and providing appropriate assistance are important challenges in social constructivist learning. These conditions demonstrate that social constructivist theory requires the support of a didactical design capable of systematically directing learning interactions.

The limitations of instructional designs that do not consider students' ways of thinking can become one of the causes of learning obstacles. Learning obstacles are not merely understood as students' inability to obtain correct answers but as difficulties that indicate differences between students' existing knowledge structures and the conceptual demands of the material being learned. Brousseau (1997) explains that learning obstacles in mathematics learning may emerge as part of the knowledge construction process and need to be analyzed in order to design more appropriate didactical situations. In the context of didactical design research, identifying learning obstacles becomes an initial step to understanding how students think and determining appropriate instructional interventions.

In mathematics learning, the analysis of learning obstacles is important because students' errors can provide information regarding their thinking processes and actual learning needs. Sidik et al. (2023) explain that didactical obstacles may occur when instructional designs are more oriented toward the logic of the subject matter rather than students' learning processes. In measurement

learning, instruction that directly focuses on formula application without providing concrete experiences may cause students' understanding to become disconnected between concepts, procedures, and contexts. Therefore, learning obstacles should be positioned as a foundation for developing instructional designs rather than merely being considered as evaluation results after learning takes place.

The need to understand learning obstacles deeply is also related to the importance of reflecting on students' responses during the learning process. Learning evaluation that only focuses on final scores is insufficient to explain why students experience difficulties or what didactical actions should be taken by teachers. Jamilah, Priskila, and Oktaviana (2024) explain that a reflective culture in mathematics learning plays an important role in improving instructional quality because it enables teachers to understand students' thinking processes more deeply. Therefore, correct responses, incorrect responses, partially correct responses, alternative strategies, and even the absence of responses should be viewed as important information for designing more adaptive learning.

Based on these needs, the development of instructional designs requires a research approach that is able to connect the analysis of learning obstacles with the processes of designing, implementing, and refining learning. Didactical Design Research (DDR) is one relevant approach because it focuses on analyzing didactical situations before learning, observing the relationship between teacher actions and students' responses during learning, and reflecting on implementation results to improve the design. Sidik et al. (2023) explain that DDR enables researchers to reconstruct didactical situations through prospective analysis, metapedadidactical analysis, and retrospective analysis. This approach positions learning as a continuous developmental process based on empirical evidence obtained from interactions among teachers, students, and learning materials.

Within the framework of Didactical Design Research (DDR), instructional design

development does not stop at the preparation of learning materials but must establish traceability between learning problems, proposed solutions, implementation processes, and reflection outcomes. In this study, the identified learning obstacles obtained through preliminary studies were translated into Design Requirements (DR) as design needs that must be fulfilled to overcome students' learning difficulties. Furthermore, DR became the basis for developing the Hypothetical Learning Trajectory (HLT), which describes learning objectives, designed activities, and predicted students' conceptual development. Suryadi (2019) explains that didactical design should consider the relationship among learning materials, students, and teachers through the analysis of didactical situations in order to anticipate various possible student responses. Therefore, the development of this design is not merely oriented toward producing instructional products but toward constructing a system of relationships among learning obstacles, learning trajectories, and teachers' didactical actions.

The prediction of students' responses is an important component in didactical design development because every learning activity may generate various ways of thinking among students. These predictions are then integrated with Didactical Pedagogical Anticipation (ADP) as alternative teacher actions when responding to students' actual responses during learning. Suryadi (2013) explains that didactical analysis needs to consider possible student responses and teachers' anticipatory actions so that learning situations can develop productively. Thus, teachers are not only transmitters of knowledge but also designers of learning situations who can adjust instructional interventions based on students' actual needs.

The integration of contextual learning and social constructivism in this study is realized through five main phases of the Contextual Didactical Design, namely problem contextualization, exploration and social discourse, collaboration and scaffolding, construction of measurement concepts, and application and reflection. The

problem contextualization phase provides opportunities for students to connect everyday experiences with mathematical concepts being learned. Furthermore, exploration and social discourse enable students to develop understanding through communication, argumentation, and strategy exchange. Vygotsky (1978) explains that social interaction plays an essential role in cognitive development because learning occurs through mediation involving language, symbols, and social support. Therefore, the use of scaffolding and peer scaffolding in instructional design becomes an important strategy to assist students in achieving higher levels of understanding.

At the stage of constructing measurement concepts, students' concrete experiences obtained through exploration activities are directed toward a more formal mathematical understanding. This process is important because mathematical concepts cannot be fully understood only through symbols and procedures but must be developed through experiences that enable students to understand the relationships among objects, representations, and abstract concepts. Bruner (1966) explains that learning processes occur through three stages of representation, namely enactive, iconic, and symbolic representations. Therefore, concrete experiences become an important foundation before students achieve abstract conceptual understanding. In the context of measurement learning, activities involving the use of measuring instruments, comparing measurement results, and interpreting data serve as bridges between real experiences and mathematical understanding.

The development of the didactical design in this study was conducted through a gradual reconstruction process, starting from Prototype I as a hypothetical didactical design, Prototype II as a validated didactical design, and Prototype III as the final didactical design. Each stage involved validation processes, implementation, analysis of students' actual responses, metapedadidactical analysis, and retrospective analysis to determine which design components should be maintained

or improved. Cobb et al. (2003) explain that design research enables the simultaneous development of educational theories and instructional practices through an iterative process between initial designs and empirical evidence obtained from classroom implementation. Therefore, the developed design is not merely an instructional product but an educational innovation supported by both theoretical and empirical foundations.

The need for learning designs based on learning obstacles has become increasingly important within the context of mathematics education in Indonesia, which emphasizes student-centered, contextual, collaborative learning and the development of reasoning abilities. The implementation of these principles requires teachers to analyze students' thinking processes, select relevant contexts, facilitate mathematical discourse, and provide adaptive support. The Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia (2022), through the implementation of the Merdeka Curriculum, emphasizes the importance of learning experiences that enable students to actively construct understanding through meaningful activities. Therefore, contextual didactical design becomes an approach that can bridge curriculum demands, social constructivism theory, the characteristics of measurement topics, and students' actual learning needs.

Based on the aforementioned explanation, the main issue in measurement learning is not only related to students' difficulties in solving mathematical problems but also concerns how learning is designed to accommodate students' ways of thinking, experiences, and learning obstacles. Social constructivism theory provides a foundation regarding the importance of interaction, discourse, the Zone of Proximal Development, scaffolding, and fading in the learning process. Contextual learning provides opportunities for students to connect mathematical concepts with real-life experiences, while DDR provides a systematic framework for designing, implementing, analyzing, and refining

didactical situations. The integration of these three perspectives enables measurement learning to develop from a procedure-oriented approach into an adaptive, meaningful, and evidence-based learning process.

Based on the gap between the demands for meaningful measurement learning and existing learning conditions that still encounter various learning obstacles, this study focuses on the development of a Contextual Didactical Design in Measurement Learning Based on Social Constructivism Theory. This study aims to identify students' learning obstacles, develop a didactical design based on these obstacles, analyze the implementation of the design in authentic learning situations, and examine the validity, practicality, and effectiveness of the developed design. Through the integration of DDR and social constructivism perspectives, this study is expected to produce an instructional design with strong theoretical and empirical traceability that supports students in constructing measurement concepts through interactive, reflective, and meaningful learning experiences.

Method

Research Type

This study employed a Sequential Exploratory Design consisting of two main phases, namely a qualitative phase and a quantitative phase. The first phase applied a qualitative approach using the Didactical Design Research (DDR) method to develop a Contextual Didactical Design for Measurement Learning Based on Social Constructivism Theory. The second phase applied a quantitative approach using a Quasi-Experimental method with a Nonequivalent Control Group Design to examine the effectiveness of the developed didactical design. The integration of these two phases aimed to describe the process of developing a design based on students' learning obstacles, produce a valid and practical didactical design, examine the implementation of the design in measurement learning, and analyze the effectiveness of the design in overcoming students' learning obstacles.

The main product developed in this study was a Contextual Didactical Design for Measurement Learning Based on Social Constructivism Theory that met the criteria of validity, practicality, and effectiveness. In addition to the main product, this study also produced supporting instructional components, including teaching modules, student worksheets (LKPD), learning media, assessment instruments, Hypothetical Learning Trajectory (HLT), and Didactical Pedagogical Anticipation (ADP). The quality of the developed product was analyzed based on Nieveen's criteria, which include validity, practicality, and effectiveness.

Research Development Design

The development of the didactical design in this study referred to four main stages, namely: (1) Needs Analysis, (2) Prototyping, (3) Evaluation, and (4) Implementation for Dissemination. In the qualitative phase, the development process was carried out through the needs analysis and prototype development stages, while the quantitative phase was conducted through the evaluation stage. The implementation for dissemination stage represented the integration of the qualitative and quantitative research results. These four stages were used to ensure that the developed learning design was systematic, adaptive, and appropriate to the needs of mathematics learning at the junior high school level.

The needs analysis stage was conducted through the identification of students' Learning Obstacles (LO) in measurement learning. The results of the identified learning obstacles were used as the basis for developing Design Requirements (DR), Hypothetical Learning Trajectory (HLT), predicted students' responses, and Didactical Pedagogical Anticipation (ADP). These components were then integrated with contextual learning principles and social constructivism through five phases of the didactical design, namely problem contextualization, exploration and social discourse, collaboration and scaffolding, construction of measurement concepts, and application and reflection.

The results of the needs analysis and design process produced Prototype I as a hypothetical didactical design. Prototype I was subsequently validated by experts and revised into Prototype II or the Validated Didactical Design. Prototype II was then tested on a limited basis to obtain information regarding the implementation of the design, the suitability of HLT with the learning process, students' predicted responses, ADP, scaffolding mechanisms, and students' actual responses. These actual responses were subsequently analyzed through the development of Actual Learning Trajectory (ALT), metapedadidactical analysis, and retrospective analysis to produce design refinement.

Metapedadidactical analysis was conducted to understand the relationship between the designed didactical situation, students' actual responses, and teachers' actions during the learning process. The predicted responses were compared with students' actual responses, while the hypothetical ADP was compared with the didactical-pedagogical actions that occurred during implementation. The results of this analysis were then integrated with ALT through retrospective analysis to determine the design components that needed to be maintained, improved, strengthened, simplified, or added. This process resulted in Prototype III as the Final Didactical Design.

Research Location and Participants

The research was conducted in West Malangke District, North Luwu Regency, South Sulawesi Province, Indonesia. The limited trial of Prototype II was conducted at UPT SMP Negeri 3 Malangke Barat and UPT SMP Negeri 4 Malangke Barat. Furthermore, the implementation of Prototype III or the Final Didactical Design and the effectiveness testing were conducted at UPT SMP Negeri 1 Malangke Barat. The research participants were selected purposively according to the requirements of each research stage. The participants included mathematics teachers and students as data sources in the preliminary study, students as subjects of the diagnostic test, two expert validators, students involved in the limited trial

stage, and students from the experimental and control classes in the main research. The experimental class received learning using the Contextual Didactical Design Based on Social Constructivism Theory, while the control class received comparative learning.

Data Collection Techniques

Data collection was conducted gradually from the Need Analysis, Prototyping, implementation, to evaluation stages. Various data collection techniques were employed to obtain complementary information and enable data triangulation.

Observation was conducted during the preliminary study, limited trial, and implementation of the final didactical design. Observation at the initial stage was used to obtain an overview of the existing conditions of measurement learning before the development of the design, while observation during implementation was used to obtain data regarding the implementation of the five phases of the didactical design and students' activities. Observation also focused on the implementation of social constructivism principles, including social interaction, mathematical discourse, the Zone of Proximal Development (ZPD), teacher scaffolding, peer scaffolding, fading, collaborative construction, and students' development of independence.

Interviews were conducted with teachers and students to obtain information regarding learning conditions, learning difficulties, learning experiences, indications of learning obstacles, and responses toward the implementation of the design. Diagnostic tests were administered during the Need Analysis stage to identify the forms and characteristics of students' learning obstacles based on strategies, errors, procedures, representations, and reasoning in solving measurement problems. The results of the diagnostic tests were confirmed through interviews and supporting data to produce the mapping of LO-1 to LO-10.

Expert validation was conducted on Prototype I, learning devices, and research instruments by two

expert validators. The validation results were used to determine the validity level of the product and served as the basis for revising Prototype I into Prototype II. Furthermore, questionnaires were administered to teachers and students to obtain practicality data, including ease of use, readability, implementation, flexibility, and acceptance of the design.

Learning outcome tests were administered in the form of pretest and posttest to the experimental and control classes. The test data were used to analyze learning outcomes, normality tests, homogeneity tests, hypothesis testing, N-Gain, and Cohen's *d* effect size. In addition to quantitative analysis, students' answers were analyzed qualitatively to examine changes in error patterns and changes in learning obstacles.

Research Instruments

The research instruments were grouped based on their functions and the stages of the research, namely instruments for needs analysis, validity assessment, practicality assessment, and effectiveness assessment. Each instrument was used to obtain evidence regarding the development process, product quality, implementation, and effectiveness of the Contextual Didactical Design Based on Social Constructivism Theory.

The needs analysis instruments consisted of observation guidelines, teacher interview guidelines, student interview guidelines, diagnostic tests, and documentation. These instruments were used to identify the initial conditions of measurement learning and to formulate learning obstacles, Design Requirements, Hypothetical Learning Trajectory (HLT), predicted students' responses, and Didactical Pedagogical Anticipation (ADP).

The validity instruments were used to assess Prototype I and its supporting instructional components through two expert validators. These instruments included validation sheets for the didactical design, teaching modules/lesson plans, student worksheets (LKPD), test instruments, observation sheets, response questionnaires, and interview guidelines. The

practicality instruments consisted of observation sheets for the implementation of the didactical design, teacher response questionnaires, student response questionnaires, interview guidelines, and field notes.

The effectiveness instruments included pretest-posttest learning outcome tests, student activity observation sheets, student worksheets (LKPD), teacher responses, and student responses. These data were analyzed integratively with learning outcomes, changes in learning obstacles, N-Gain, and effect size to determine the effectiveness of the developed design.

Data Analysis Techniques

Data analysis was conducted according to the characteristics of the data, the development stages, and the research objectives. The analysis included qualitative data analysis, validity analysis, practicality analysis, quantitative/effectiveness analysis, analysis of changes in learning obstacles, and integration of qualitative and quantitative data from the Need Analysis, Prototyping, implementation, and evaluation stages.

Qualitative data analysis was conducted through three stages: data condensation, data display, and verification or conclusion drawing. This analysis was used to produce evidence of the development process of the design, beginning from the initial learning conditions, identification of learning obstacles, formulation of Design Requirements, development of HLT, ADP, Prototype I development, Prototype II trial, until the formation of Prototype III as the final didactical design.

Quantitative analysis was conducted to determine the validity, practicality, and effectiveness levels of the developed design. The effectiveness of the design was analyzed based on students' learning outcomes, learning activities, students' responses, improvement of learning outcomes through N-Gain, differences in learning outcomes between the experimental and control classes through hypothesis testing, and the magnitude of the effect through Cohen's *d* effect size.

RESULTS

Development Process of the Contextual Didactical Design Based on Social Constructivism Theory According to Learning Obstacles in Measurement Learning

The development of the Contextual Didactical Design Based on Social Constructivism Theory was conducted through a systematic development process by positioning students' Learning Obstacles (LO) as the primary foundation for designing the learning design. The development stages began with Need Analysis, identification of learning obstacles, formulation of Design Requirements (DR), development of Hypothetical Learning Trajectory (HLT), prediction of students' responses, development of Didactical Pedagogical Anticipation (ADP), development of Prototype I, validation, trials, metapedadidactical analysis, retrospective analysis, and finally resulted in Prototype III as the final didactical design.

Identification of Learning Obstacles in Measurement Learning

The identification of learning obstacles was conducted through an analysis of diagnostic test results, interviews, classroom observations, analysis of students' work, and other supporting data. The diagnostic test results were not only analyzed based on whether students' answers were correct or incorrect, but also based on their problem-solving strategies, conceptual errors, procedures, representations, and reasoning. Furthermore, these findings were confirmed through interviews and observations to obtain a more comprehensive mapping of students' learning obstacles.

The analysis results indicated that students' learning obstacles in measurement learning were not only related to computational abilities but also involved conceptual understanding, the use of representations, connections among concepts, selection of problem-solving strategies, and the ability to apply measurement concepts in authentic problems.

Based on the results of data triangulation, this study identified ten learning obstacles (LO-1 to

LO-10) that became the foundation for developing the didactical design.

Table 1. Types of Learning Obstacles in Measurement Learning

Code	Main Type	Characteristics of Learning Obstacles
LO-1	Ontogenic/Epistemological	The meaning of measurement and standardization of units are not yet fully understood; measurement results may still be written as numbers without units.
LO-2	Didactical/Procedural	Errors in the use of the zero point, reading scales, instrument positioning, and understanding length as the difference between initial and final readings.
LO-3	Epistemological	Estimation, repeated measurements, variation of results, and accuracy are not yet adequately understood.
LO-4	Epistemological	Students experience difficulties distinguishing the concepts of perimeter and area.
LO-5	Epistemological	Understanding of square units and area conversion remains limited.
LO-6	Epistemological	Volume is understood as formula application rather than constructed through the concept of cubic units and spatial arrangement.
LO-7	Epistemological	The relationship between volume and capacity has not been understood meaningfully.
LO-8	Epistemological	Scale is understood as a mechanical procedure without understanding the relationship between image ratios and actual conditions.
LO-9	Epistemological	Students experience difficulties in selecting and integrating concepts, instruments, units, representations, and strategies in authentic problems.
LO-10	Didactical/Social-Communicative	Unequal participation, answers without explanations, dependence on teachers or peers, and low mathematical discourse abilities.

Source: Results of Learning Obstacles Identification and Verification.

The verification results showed that LO-1 to LO-9 were primarily identified through students' responses to measurement concepts and problems. LO-1 was related to understanding the meaning of measurement and unit standardization; LO-2 was related to the use of zero points, scale reading, and interpreting length as a difference between measurements; LO-3 was related to estimation, repeated measurements, variation, and accuracy; LO-4 and LO-5 were related to two-dimensional structures; LO-6 and

LO-7 were related to volume and capacity; LO-8 was related to scale ratio concepts; while LO-9 was related to students' ability to select and integrate concepts in authentic problems.

Unlike the other learning obstacles, LO-10 had characteristics related to didactical and social-communicative aspects, meaning that it could not be identified solely through written tests. This obstacle was verified through observations of classroom interactions and interviews related to mathematical discourse, group dominance,

dependence on assistance, and the development of students' independence.

Based on the identification results, a relationship was obtained between learning obstacles and instructional design requirements. LO-1 to LO-3 indicated the need for concrete experiences leading toward standardized measurement and accuracy. LO-4 and LO-5 directed the development of two-dimensional structures. LO-6 and LO-7 guided the construction of three-dimensional structures and the relationship between volume and capacity. LO-8 required reinforcement of ratio concepts and representations, while LO-9 and LO-10 required authentic problems, social discourse, scaffolding, mediation through tools and representations, application, and reflection.

Formulation of Design Requirements (DR)

Based on the identification results of learning obstacles, the next stage was transforming the learning obstacles into design requirements. The formulation of Design Requirements (DR) was conducted to ensure that each component of the instructional design had traceability to the learning obstacles that needed to be addressed.

The transformation results from LO into DR indicated that measurement learning design requires several main characteristics, including concrete experiences, the use of authentic contexts, the use of measuring instruments, transitions from informal representations to formal representations, social discourse, collaboration, scaffolding, peer scaffolding, application, and reflection.

In detail, LO-1 to LO-3 resulted in the need for concrete measurement experiences, unit standardization, the use of measuring instruments, estimation, repeated measurements, and accuracy. LO-4 and LO-5 resulted in the need to construct the concepts of boundaries and regions as well as the use of square units. LO-6 and LO-7 resulted in the need to construct volume through cubic units and connect it with capacity. LO-8 required ratio experiences through contextual representations such as maps or drawings. LO-9 required authentic problems

that encouraged students to select appropriate strategies, while LO-10 required the organization of discourse, collaboration, scaffolding, and the development of students' independence.

Development of Hypothetical Learning Trajectory (HLT), Students' Predicted Responses, and Didactical Pedagogical Anticipation (ADP)

Based on the identification of Learning Obstacles and the formulation of Design Requirements, the next stage in the development of the didactical design was the construction of the Hypothetical Learning Trajectory (HLT). The development of HLT considered the progression of students' understanding from informal measurement experiences toward formal and applicable understanding of measurement concepts. The developed HLT not only described the trajectory of mathematical concept development but also considered students' socio-pedagogical development through interaction, discussion, scaffolding, peer scaffolding, fading, and the development of independent learning.

The development results showed that the learning trajectory of measurement concepts needed to progress gradually through the following stages:

1. informal measurement experiences;
2. standardization of units;
3. the use of measuring instruments and accuracy;
4. the concept of length;
5. the concepts of perimeter and area;
6. the concepts of volume and capacity;
7. the concepts of scale and maps;
8. integrated application of measurement concepts;
9. reflection and development of students' independence.

The learning trajectory was then developed into five learning meetings. The first meeting focused on the concepts of length, units, estimation, and accuracy. The second meeting discussed perimeter, area, and area unit conversion. The third meeting focused on volume and capacity. The fourth meeting addressed scale and maps.

The fifth meeting was used for the integrated application of various measurement concepts.

Table 2. Hypothetical Learning Trajectory of Measurement Learning

Meeting	Concept Focus	Main Activities	Development of Understanding
1	Length, units, estimation, and accuracy	Measuring real objects, comparing measurement results, and using measuring instruments	Moving from informal experiences toward standardized measurement
2	Perimeter, area, and area unit conversion	Exploring boundaries and regions through contextual objects	Constructing relationships among perimeter, area, and square units
3	Volume and capacity	Constructing volume through arrangements of cubic units and connecting it with capacity	Understanding volume as a spatial structure rather than merely a formula
4	Scale and maps	Comparing drawing sizes with actual sizes	Understanding scale as a ratio relationship
5	Application of measurement concepts	Solving integrated authentic problems	Integrating concepts, strategies, representations, and reflection

Source: Results of the HLT development in this study.

Students' Predicted Responses

The development of HLT resulted in the need to predict various possible students' responses during the learning process. Response prediction was conducted because, in social constructivism-based learning, students' responses may develop differently according to their prior experiences, conceptual understanding, and the social interaction processes occurring during learning.

The research results showed that one learning activity could generate several types of students' responses, namely :

1. Expected responses, which indicate that students have understood the intended concept.
2. Partial responses, which indicate that students have partially understood the concept but still experience conceptual limitations.
3. Responses that indicate remaining learning obstacles, which show that certain learning difficulties have not yet been overcome.

4. New unexpected responses, which emerge during the learning process and require adjustments in teachers' instructional actions.

These predicted responses were then used as the basis for developing Didactical Pedagogical Anticipation (ADP).

Didactical Pedagogical Anticipation (ADP)

ADP was developed as a form of teacher preparedness in responding to possible difficulties or developments in students' understanding during the learning process. ADP does not merely consist of providing answers or correcting students' errors, but involves didactical actions that assist students in constructing understanding through experiences, discussions, prompting questions, the use of representations, and gradual assistance.

In the developed design, ADP was directed toward overcoming the identified learning obstacles. For example, for obstacles related to understanding measurement and units, students

were provided with direct experiences using measuring instruments and comparing measurement results. For obstacles related to perimeter and area, students were guided to distinguish the concepts of boundaries and regions through concrete activities. For obstacles related to volume and capacity, students were guided to construct concepts through cubic units and the relationship between spatial structures and capacity.

In addition to teacher assistance, the design also developed peer scaffolding, namely assistance among students through discussion and collaboration activities. This is consistent with the finding that students' learning development is

not only influenced by interaction with teachers but also through social interaction with peers.

Development of Prototype I: Contextual Hypothetical Didactical Design

The integration of Learning Obstacles, Design Requirements, Hypothetical Learning Trajectory (HLT), predicted students' responses, and Didactical Pedagogical Anticipation (ADP) resulted in Prototype I as a Contextual Hypothetical Didactical Design. Prototype I was designed based on the principle that measurement learning should provide learning experiences that move from concrete activities toward the abstraction of mathematical concepts. Therefore, the design was developed through five main learning phases :

Table 3. Phases of Contextual Didactical Design

Phase	Characteristics of Learning Activities
Problem Contextualization	Students are presented with real-world problems related to measurement to activate their prior experiences.
Exploration and Social Discourse	Students explore problems, conduct measurements, and discuss strategies.
Collaboration and Scaffolding	Students construct understanding through cooperation and gradual assistance.
Construction of Measurement Concepts	Students connect concrete experiences with formal mathematical concepts.
Application and Reflection	Students apply concepts to new problems and reflect on the learning process.

Source: Results of the Contextual Didactical Design development.

These five phases were developed to ensure that the learning process was not only oriented toward final learning outcomes but also considered the process of students' knowledge construction. Overall, Prototype I represented an initial design that described the relationship between students' learning obstacles and instructional design requirements. This prototype subsequently became the foundation for the expert validation stage, design revision, and the development of Prototype II.

Validation of Didactical Design and Development of Prototype II

Validation Results of Prototype I

Prototype I represented a Contextual Hypothetical Didactical Design developed based on the integration of Learning Obstacles (LO), Design Requirements (DR), Hypothetical Learning Trajectory (HLT), predicted students' responses, and Didactical Pedagogical Anticipation (ADP). At this stage, the design was still hypothetical because the learning trajectory and students' responses were based on predictions that needed to be examined through expert validation and empirical implementation.

Validation was conducted on the main structure of the didactical design and its supporting instructional components. The validated

components included the Contextual Didactical Design, Teaching Module/Lesson Plan, Student Worksheets (LKPD), measurement media or instruments, learning assessment, and research instruments.

Validation was carried out by two expert validators to ensure the alignment between learning problems, theoretical foundations, learning trajectories, learning activities, instructional components, and assessments.

The validation results showed that all development components were categorized as highly valid. This validity indicates that the developed design demonstrated consistency between the empirical foundation in the form of learning obstacles, the design foundation represented by the LO–DR–HLT–ADP relationship, and the social constructivism theory used as the basis for development.

Table 4. Validation Results of Prototype I

Validated Components	Validation Results
Contextual Didactical Design	Highly Valid
Teaching Module/Lesson Plan	Highly Valid
Student Worksheets (LKPD)	Highly Valid
Measurement Media/Instruments	Highly Valid
Learning Assessment	Highly Valid
Research Instruments	Highly Valid

Source: Expert validation results of Prototype I.

Although Prototype I obtained a highly valid category, the validators provided several recommendations for improvement. The revisions mainly focused on the clarity of learning activity instructions, consistency in the use of terminology, the relationship between teacher and student activities, the relationship among learning phases, the traceability between LKPD and the didactical design, and the operationalization of scaffolding and fading.

These revisions did not change the main structure of the design but were directed toward improving operational aspects so that the design could be implemented more clearly in authentic classroom learning.

Development of Prototype II as a Validated Didactical Design

Based on the validation results and recommendations from the validators, revisions were made to Prototype I, resulting in Prototype II as a Validated Didactical Design. Prototype II was not merely the result of technical improvements but represented a design with a

clearer implementation structure regarding the relationship among:

1. Learning Obstacles (LO);
2. Design Requirements (DR);
3. Hypothetical Learning Trajectory (HLT);
4. predicted students' responses;
5. Didactical Pedagogical Anticipation (ADP);
6. five phases of didactical design;
7. teacher and student activities;
8. student worksheets (LKPD); and
9. learning assessments.

In Prototype II, the predicted responses and ADP were clarified so that teachers had alternative instructional actions when students encountered obstacles during the learning process. In addition, the implementation components were adjusted based on the validators' recommendations to make them more applicable in authentic classroom situations.

However, Prototype II was not yet determined as the final design. Expert validation provided

evidence regarding the conceptual feasibility of the design but did not yet provide evidence regarding its practicality, the suitability between predicted and actual students' responses, the effectiveness of ADP, and the development of the learning trajectory during classroom implementation. Therefore, Prototype II still needed to be examined through a limited trial.

Limited Trial of Prototype II

A limited trial was conducted on Prototype II to obtain empirical evidence regarding the implementation of the design in measurement learning. This trial aimed to determine:

1. whether the five phases of the didactical design could be implemented;
2. how students responded to the learning activities;
3. how teachers implemented scaffolding, peer scaffolding, and fading;
4. which components of the design still required improvement.

The results of the limited trial showed that, in general, the five phases of the didactical design could be implemented in measurement learning. Students were able to participate in learning activities starting from the presentation of contextual problems, exploration, the use of objects and measuring instruments, group discussions, collaboration, concept construction, application, and reflection.

During implementation, teachers began to perform their role as facilitators by providing guiding questions (probing), scaffolding, peer scaffolding, and fading. However, the trial results also indicated several aspects that still required improvement, including:

1. clarity of learning instructions;
2. time management;
3. equal distribution of student participation;

4. appropriateness of providing and reducing scaffolding;
5. verification of measurement results;
6. consistency in the use of units;
7. individual student reflection.

These findings indicated that the issues identified in Prototype II were primarily operational aspects, while the main structure of the design, consisting of LO, DR, and the learning trajectory, did not undergo fundamental changes. Therefore, the results of the Prototype II trial became the basis for conducting metapedadidactical analysis, developing the Actual Learning Trajectory (ALT), performing retrospective analysis, and refining the design toward Prototype III as the final didactical design.

Implementation of Contextual Didactical Design and Reconstruction of Prototype III

The implementation of the Contextual Didactical Design was conducted after Prototype III was established as the Final Didactical Design. Prototype III represented the refinement of Prototype II through a series of processes including expert validation, limited trials, analysis of students' actual responses, metapedadidactical analysis, reconstruction of the Actual Learning Trajectory (ALT), comparison between HLT and ALT, analysis of changes in learning obstacles, and retrospective analysis. Therefore, Prototype III was not merely a technical revision but a synthesis between the prospective design developed based on learning obstacles and empirical evidence obtained from classroom learning implementation.

Implementation of the Final Didactical Design

The Final Didactical Design was implemented in measurement learning while maintaining the five main phases of the design :

Table 5. Implementation Phases of Contextual Didactical Design

Didactical Design Phase	Learning Activities
Problem Contextualization	Students are presented with problems related to real situations to activate their prior knowledge about measurement.

Exploration and Social Discourse	Students conduct exploration, perform measurements, present strategies, and discuss with group members.
Collaboration and Scaffolding	Teachers provide assistance based on students' responses through guiding questions and instructional support.
Construction of Measurement Concepts	Students connect concrete experiences with formal mathematical concepts.
Application and Reflection	Students apply concepts to new problems and reflect on the learning process.

The five phases were maintained in Prototype III because they had been proven capable of connecting students' learning needs with the process of knowledge construction. Prototype III was more adaptive compared with Prototype II because the provision of assistance (scaffolding) was not implemented uniformly but adjusted according to students' actual responses. Teachers initially provided minimal assistance and increased the level of support when students experienced difficulties. When students were able to demonstrate appropriate strategies, reasoning,

or representations, the assistance was gradually reduced through the fading process

Reconstruction of Learning Trajectory Based on Students' Actual Responses

The implementation of Prototype III generated data on students' actual responses, which were used to reconstruct the Actual Learning Trajectory (ALT). The ALT reconstruction was conducted by comparing the previously designed Hypothetical Learning Trajectory (HLT) with the development of students' understanding during the learning process.

Table 6. Comparison between HLT and ALT in the Implementation of the Final Didactical Design

Component	HLT (Hypothetical Trajectory)	ALT (Actual Trajectory)
Initial measurement experiences	Students understand measurement through concrete experiences	Students begin to connect measurement activities with the concept of units
Use of measuring instruments	Students are able to use measuring instruments and understand accuracy	Students require reinforcement in verifying measurement results and maintaining unit consistency
Perimeter and area	Students construct relationships between boundaries and regions	Students demonstrate development through discussions and representations
Volume and capacity	Students understand volume through spatial units	Students require reinforcement in understanding the relationship between volume and capacity
Scale and maps	Students understand the relationship between drawing sizes and actual sizes	Students develop understanding through authentic contexts

Source: Results of HLT and ALT analysis in the implementation of the Final Didactical Design.

The analysis results showed that HLT-1 to HLT-6 were generally confirmed through ALT. However, the implementation provided several reinforcements regarding the verification of measurement results, consistency in the use of units, selective provision of scaffolding, fading processes, and individual reflection by students.

Metapedadidactical Analysis in Design Implementation

Metapedadidactical analysis was conducted to examine the relationship among three main

components in the learning process, namely: the designed didactical situation → students' responses → teacher actions.

The implementation results showed that the learning design was not static but underwent adjustments according to students' actual conditions. The predicted responses developed in HLT became the initial basis for teachers' instructional actions; however, students' actual responses became the main consideration in determining the form of assistance provided.

Table 7. Results of Metapedadidactical Analysis

Analysis Component	Implementation Findings
Didactical situation	Contextual problems were able to generate students' prior experiences and strategies
Students' responses	Various strategies, conceptual errors, and needs for assistance emerged
Teacher actions	Teachers adjusted scaffolding, guiding questions, and reduction of assistance
Learning development	Students moved toward more formal conceptual understanding

The implementation showed that social relationships in learning became an important component in the development of students' understanding. Interaction with teachers and peers assisted students in clarifying ideas, comparing strategies, and constructing shared understanding.

Retrospective analysis was conducted by comparing the planned design with the actual learning process that occurred during implementation. This analysis was used to determine which design components should be maintained and which components required improvement.

Retrospective Analysis and Refinement of Prototype III

Table 8. Results of Retrospective Analysis from Prototype II to Prototype III

Design Component	Reconstruction Results
Learning Obstacles	Maintained as the foundation of the design
Design Requirements	Maintained and strengthened
HLT	Maintained with adjustments based on ALT
ADP	Modified to become more flexible according to students' responses
Scaffolding	Provided selectively
Fading	Strengthened to improve students' independence
Reflection	Strengthened through individual reflection

Characteristics of Prototype III as the Final Didactical Design

Based on the reconstruction results, Prototype III had the following characteristics:

Table 9. Characteristics of the Final Didactical Design

Aspect	Characteristics of Prototype III
Development foundation	Based on learning obstacles
Approach	Contextual and social constructivism-based
Learning interaction	Social-interactive through discourse and collaboration
Learning assistance	Adaptive through scaffolding and fading
Learning trajectory	Verified through HLT and ALT
Anticipation	Flexible based on students' actual responses
Aspect	Characteristics of Prototype III

Prototype III was established as the Final Didactical Design because it integrated Learning Obstacles (LO), Design Requirements (DR), Hypothetical Learning Trajectory (HLT), Didactical Pedagogical Anticipation (ADP), students' actual responses, Actual Learning Trajectory (ALT), metapedadidactical actions, and retrospective analysis results. Therefore, the final design is not merely an instructional product, but an evidence-based learning design developed through a continuous cycle of analysis, implementation, evaluation, and reconstruction.

Practicality of the Contextual Didactical Design Based on Social Constructivism Theory

The practicality of the Contextual Didactical Design was analyzed after Prototype III was established as the final didactical design and implemented in measurement learning. The practicality analysis was conducted to determine

the extent to which the developed design could be used in authentic learning situations, both in terms of the implementation of learning stages, students' activities, and users' responses toward the implemented design.

The practicality of the design was not only evaluated based on the use of instructional components but also based on the compatibility between the developed design components and the actual learning process. This included the relationship among Learning Obstacles (LO), Design Requirements (DR), HLT/ALT, ADP, the five phases of didactical design, instructional components, and learning assessments.

Implementation of the Contextual Didactical Design

The implementation of the final didactical design was conducted through five main phases, namely:

Table 10. Components of Contextual Didactical Design Implementation

Didactical Design Phase	Implementation Focus
Problem Contextualization	Presenting measurement problems related to real-life contexts
Exploration and Social Discourse	Providing opportunities for students to explore and exchange ideas
Collaboration and Scaffolding	Providing learning assistance according to students' needs
Construction of Measurement Concepts	Connecting concrete experiences with formal concepts

Application and Reflection	Applying concepts to new problems and conducting reflection
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The final design maintained these five phases but had more adaptive characteristics compared with previous prototypes. During implementation, teachers were not required to apply all forms of ADP simultaneously but selected appropriate assistance based on students' actual responses. Assistance was provided gradually, beginning with minimal support and increasing to more intensive support when necessary. After students demonstrated the ability to develop strategies and provide appropriate reasoning, the assistance was reduced through the fading process.

Students' Activities in Design Implementation

The implementation results showed that the contextual didactical design was able to facilitate learning activities aligned with the principles of social constructivism. Students did not merely receive information from teachers but were actively involved in exploration, discussion, collaboration, concept construction, application, and reflection processes.

Table 11. Students' Activities in the Contextual Didactical Design

Activity Aspect	Activity Form
Exploration	Observing, trying, and conducting measurements
Social discourse	Presenting ideas and comparing strategies
Collaboration	Working together in solving problems
Concept construction	Connecting experiences with mathematical concepts
Reflection	Evaluating strategies and understanding

These activities indicate that learning was not only oriented toward final outcomes but also considered the process of constructing understanding through social interaction. This finding is consistent with the characteristics of Prototype III, which is based on learning obstacles, contextual learning, constructivist principles, social interaction, adaptability, and a learning trajectory that has been confirmed through ALT'.

Teacher and Student Responses Toward the Design

The practicality of the design was also analyzed through teacher and student responses as users of the instructional design.

Table 12. Aspects of Responses Toward the Didactical Design

Respondent	Observed Aspects
Teacher	Ease of design implementation, implementation of learning phases, use of ADP, discussion management, and provision of assistance
Students	Attractiveness of contexts, ease of following activities, involvement in discussions, and learning experiences

The implementation results showed that the design provided opportunities for teachers to make adjustments according to students' needs. This was reflected in the change in the function of ADP in Prototype III, which became more

flexible compared with Prototype II. Teachers provided assistance based on students' actual responses rather than following a rigid sequence of instructional support.

Practicality Findings of the Didactical Design

Based on the implementation process, the contextual didactical design demonstrated several practicality characteristics:

1. Applicable in authentic learning situations : Prototype III had undergone validation, limited trials, analysis of actual responses, and retrospective analysis before being implemented on a broader scale. Therefore, the design had empirical support for classroom implementation.
2. Easily adaptable to students' responses : The design provided flexible ADP, enabling teachers to adjust the type of assistance according to students' learning needs.
3. Supporting social constructivism-based learning processes : The design maintained social interaction, discourse, collaboration, scaffolding, peer scaffolding, fading, concept construction, application, and reflection as essential components of implementation.

Practicality of the Contextual Didactical Design Based on Social Constructivism Theory

The practicality of the Contextual Didactical Design was analyzed to determine the extent to which the developed design could be implemented in authentic learning conditions. The practicality analysis was conducted based on observations of didactical design implementation, teacher responses, student responses, interviews, and field notes. These data were used to examine the ease of use, implementation of learning phases, flexibility of the design, and user acceptance toward the developed didactical design.

Table 12. Observation Results of Students' Activities

Component	Result
Students' activity score	90%
Category	Very Active

The practicality analysis focused on three main components, namely the implementation of the didactical design, teacher responses, and student responses. Implementation observations were used to determine the achievement of the five didactical design phases, namely (1) Problem Contextualization, (2) Exploration and Social Discourse, (3) Collaboration and Scaffolding, (4) Construction of Measurement Concepts, and (5) Application and Reflection.

Implementation of the Contextual Didactical Design

The implementation results showed that the contextual didactical design could be applied in measurement learning through the planned learning stages. Students participated in the learning process through exploration activities, social discussions, the use of scaffolding, concept construction, and application and reflection activities.

Based on the results of learning activity observations, the contextual didactical design was able to create a learning process that actively involved students. Students did not merely receive information but were engaged in constructing understanding through interaction and meaningful learning experiences.

Students' Activities in the Implementation of the Didactical Design

The observation results of students' activities showed that the implementation of the contextual didactical design was able to increase students' engagement during the learning process.

Based on the observation results, the average percentage of students' activities reached 90%. This result indicates that students were categorized as very active during learning using the contextual didactical design.

Students' activities demonstrated their involvement in various learning processes,

including conducting exploration, applying problem-solving strategies, utilizing teacher probing and scaffolding, constructing concepts based on discussion results, applying concepts to new situations, and reflecting on the understanding they had developed.

Students' Responses Toward the Contextual Didactical Design

Students' responses were analyzed to determine their acceptance of learning using the contextual didactical design.

Table 13. Students' Responses Toward the Contextual Didactical Design

Student Response Indicators	Total Score	Maximum Score	Percentage
Learning Engagement and Activities	578	660	88%
Social Interaction and Learning Support	573	660	87%
Mathematical Understanding and Connections	680	792	86%
Motivation, Self-Confidence, and Independence	443	528	84%
Total	2274	2640	86%

Based on these results, all indicators of students' responses obtained a good category. The learning engagement and activities indicator obtained a percentage of 88%, social interaction and learning support obtained 87%, mathematical understanding and connections obtained 86%, while motivation, self-confidence, and independence obtained 84%. Overall, students' responses obtained a score of 86%, indicating that learning using the contextual didactical design was categorized as good.

Effectiveness of the Contextual Didactical Design Based on Social Constructivism Theory

The effectiveness of the contextual didactical design was analyzed based on the achievement of

the research effectiveness indicators, namely students' activities, students' responses, and students' learning outcomes. The contextual didactical design was considered effective when students' activities reached at least the active category, students' responses reached at least the good category, and students' learning outcomes achieved mastery according to the established Minimum Learning Achievement Criteria (KKTP).

Students' Learning Outcomes After the Implementation of the Didactical Design

Learning outcome analysis was conducted based on students' posttest scores after the implementation of the contextual didactical design.

Table 14. Students' Learning Outcomes

Analysis Component	Result
Average posttest score	80.45
KKTP	70
Conclusion	Achieved

The analysis results showed that the average posttest score of students was 80.45. This score was higher than the established KKTP, which was 70. Therefore, the implementation of the contextual didactical design fulfilled the success criteria for students' learning outcomes.

Classical Mastery of Learning Outcomes

Table 15. Students' Classical Mastery Achievement

Component	Result
Percentage of students achieving mastery	82%
Classical mastery criterion	80%
Conclusion	Achieved

The research results showed that the percentage of students achieving classical mastery after the implementation of the contextual didactical design was 82%. This result fulfilled the predetermined classical mastery criterion of 80%. Therefore, the contextual didactical design was considered effective in improving students' mathematics learning outcomes.

Improvement of Learning Outcomes Based on N-Gain

Table 16. Normalized Gain Analysis Results

Component	Result
Average N-Gain	0.78
Category	High

The calculation results showed that the average normalized gain of students was 0.78. This value was higher than the threshold for the medium category (0.30), indicating that the improvement of learning outcomes after the implementation of the contextual didactical design was categorized as high.

Effectiveness Based on Students' Responses and Activities

Table 17. Recapitulation of Effectiveness Indicators of the Contextual Didactical Design

Effectiveness Indicator	Result	Category
Average learning outcomes	80.45	Achieved
Classical mastery	82%	Achieved
N-Gain	0.78	High
Students' responses	86%	Good
Students' activities	90%	Very Active

Based on all effectiveness indicators, the Contextual Didactical Design Based on Social Constructivism Theory was considered effective for implementation in measurement learning. The effectiveness was demonstrated not only through the improvement of students' learning outcomes but also through the high level of students' activities, positive students' responses, and students' involvement in the process of concept construction through social interaction, scaffolding, and reflection.

Discussion

Development of Contextual Didactical Design Based on Learning Obstacles in Measurement Learning

The results of the study showed that the development of the Contextual Didactical Design was conducted based on the analysis of learning obstacles identified in measurement learning. The identified learning obstacles were not only related to procedural errors in performing calculations but also involved

conceptual, epistemological, didactical, and social-communicative obstacles experienced by students.

These findings indicate that measurement learning cannot be directed solely toward mastering mathematical formulas and procedures. Students require learning experiences that enable them to construct conceptual meanings through concrete activities, the use of real-world contexts, social interaction, and reflection processes.

The development of the design based on learning obstacles was important because the learning obstacles experienced by students became the foundation for determining learning needs (Design Requirements). Therefore, the developed design was not a general instructional design but was specifically designed based on students' actual learning conditions.

This finding is consistent with the principles of Didactical Design Research (DDR), which positions learning obstacles as the starting point for designing didactical situations. Instructional design is not only oriented toward the material that teachers need to deliver but also considers students' possible ways of thinking, potential errors that may emerge, and anticipatory actions that need to be prepared.

In this study, the relationship among learning obstacles, Design Requirements, HLT, predicted responses, and ADP became the main components in producing an adaptive didactical design. This process demonstrates that instructional design was developed through a cycle of prospective and retrospective analysis, resulting in a design that was aligned with students' learning needs.

The Role of Social Constructivism Theory in the Implementation of Contextual Didactical Design

The results showed that the implementation of the contextual didactical design was able to create a learning environment that positioned students as active individuals in constructing knowledge. This was demonstrated by students' activity level

reaching 90% and students' responses reaching 86%.

The high level of student activity indicates that learning was no longer fully teacher-centered but provided opportunities for students to explore, discuss, present strategies, compare ideas, and construct understanding through social interaction.

These findings are consistent with the principles of social constructivism theory, which views students' cognitive development as occurring through interaction with the social environment. Knowledge is not merely transferred from teachers to students but is constructed through experience and communication processes.

In the developed design, the principles of social constructivism were implemented through several main components:

1. Social Discourse : Students were provided with opportunities to express ideas, explain strategies, and compare various problem-solving approaches.
2. Collaboration: Students worked together to solve the given measurement problems.
3. Scaffolding : Teachers provided assistance according to students' needs through guiding questions, directions, and conceptual reinforcement.
4. Fading : Teacher assistance was gradually reduced so that students could solve problems independently.

Therefore, the success of the design was not only determined by the instructional components but also by the quality of social interactions that occurred during the learning process.

Effectiveness of the Contextual Didactical Design in Improving Learning Outcomes

The results of the study showed that the Contextual Didactical Design was effective when implemented in measurement learning. This effectiveness was demonstrated through several indicators, namely the average posttest score of 80.45, classical mastery achievement of 82%, and an N-Gain value of 0.78.

The improvement in learning outcomes indicates that the learning experiences provided through the contextual didactical design were able to assist students in understanding measurement concepts in a more meaningful way.

Measurement learning, which previously tended to focus on the use of formulas and procedures, experienced a transformation into learning that involved direct experiences. Students were provided with opportunities to conduct measurements, use measuring instruments, interpret measurement results, discuss strategies, and connect mathematical concepts with real-life situations.

The N-Gain value of 0.78 indicates that students' improvement in learning ability was categorized as high. This finding demonstrates that the developed didactical design not only assisted students in solving problems but also supported the construction of conceptual understanding through systematic learning experiences.

Changes in Learning Obstacles After the Implementation of the Didactical Design

One of the main contributions of this study is demonstrating that the didactical design not only improved learning outcomes but also assisted in overcoming students' learning obstacles. Before the implementation of the design, students experienced various obstacles, including:

1. difficulties in understanding the meaning of measurement;
2. inaccuracies in the use of units;
3. difficulties in distinguishing the concepts of perimeter and area;
4. understanding volume that was still oriented toward formula application;
5. difficulties in applying concepts to authentic problems.

Through the implementation of the contextual didactical design, these obstacles were addressed through gradual and structured learning experiences.

For example, difficulties in understanding measurement concepts were addressed through direct measurement activities using real objects.

Obstacles related to area and volume concepts were addressed through the construction of concepts using concrete representations before moving toward formal mathematical symbols.

This finding indicates that changes in students' understanding did not occur merely through the delivery of information but through a process of knowledge reconstruction based on meaningful learning experiences.

Contribution of the Study to the Development of Measurement Learning

This study provides theoretical and practical contributions to the development of mathematics learning, particularly in the topic of measurement.

Theoretically, this study strengthens the argument that the development of learning designs based on learning obstacles can produce learning processes that are more responsive to students' ways of thinking.

Practically, this study produces a Contextual Didactical Design that can be used as an alternative approach for measurement learning with the following characteristics:

1. based on students' learning obstacles;
2. using real-world contexts;
3. developing social interaction;
4. implementing scaffolding and fading;
5. providing opportunities for reflection;
6. integrating the process of concept construction with application.

Therefore, the developed design not only improves students' learning outcomes but also builds more meaningful learning experiences for students.

Conclusion

Based on the results of the study regarding the development of the Contextual Didactical Design Based on Social Constructivism Theory According to Learning Obstacles in Measurement Learning, it can be concluded that the developed instructional design was able to provide solutions to students' learning obstacles

and improve the quality of the measurement learning process and outcomes.

First, the identification results of learning obstacles showed that students' learning obstacles in measurement learning were not only related to procedural errors but also included conceptual, epistemological, didactical, and social-communicative obstacles. These obstacles included difficulties in understanding the meaning of measurement, the use of units, the use of measuring instruments, estimation and accuracy, understanding perimeter and area, volume and capacity concepts, scale concepts, the ability to integrate various concepts in authentic problems, and the ability to interact and engage in mathematical discussions.

Second, the development of the Contextual Didactical Design was conducted through systematic stages beginning with needs analysis, identification of learning obstacles, formulation of Design Requirements, development of Hypothetical Learning Trajectory (HLT), prediction of students' responses, development of Didactical Pedagogical Anticipation (ADP), validation, implementation, metapedadidactical analysis, analysis of Actual Learning Trajectory (ALT), and retrospective analysis. This process resulted in Prototype III as the Final Didactical Design, which integrated the relationship among learning obstacles, design requirements, learning trajectories, students' actual responses, and teachers' didactical actions.

Third, the implementation of the Contextual Didactical Design showed that the design was able to create learning processes aligned with the principles of social constructivism. Learning was

conducted through five main phases, namely problem contextualization, exploration and social discourse, collaboration and scaffolding, construction of measurement concepts, and application and reflection. Through these stages, students were actively involved in constructing understanding through real experiences, social interaction, the use of measuring instruments, discussion, and reflection. The implementation results also showed that Prototype III had adaptive characteristics because teachers were able to adjust the provision of assistance based on students' actual responses.

Fourth, the Contextual Didactical Design was proven to be effective when implemented in measurement learning. This effectiveness was demonstrated through students' learning outcomes, with an average posttest score of 80.45, classical mastery achievement of 82%, and improvement in students' abilities based on an N-Gain value of 0.78 categorized as high. In addition, students' activities reached 90% with a very active category, and students' responses toward learning reached 86% with a good category. These results indicate that the developed didactical design not only improved students' cognitive achievement but also enhanced students' engagement, social interaction, motivation, and independent learning.

Therefore, the Contextual Didactical Design Based on Social Constructivism Theory can serve as an alternative evidence-based instructional design for measurement learning because it was developed based on students' actual learning obstacles and refined through systematic implementation and reflection processes.

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