

Constructivist approach through portfolio assessment to enhance mathematical conceptual understanding: A case study among university students

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Abstrak Penelitian ini bertujuan menganalisis implementasi pendekatan konstruktivistik melalui penilaian portofolio dalam meningkatkan kemampuan pemahaman konsep matematis mahasiswa. Penelitian dilakukan pada salah satu perguruan tinggi swasta di Lombok Timur menggunakan pendekatan kualitatif dengan desain studi kasus. Data diperoleh melalui observasi, wawancara mendalam, dan analisis dokumen portofolio mahasiswa. Hasil penelitian mengindikasikan bahwa pendekatan konstruktivistik berbasis portofolio mampu mengubah paradigma pembelajaran dari berpusat pada dosen menuju pembelajaran reflektif dan kolaboratif. Mahasiswa menunjukkan peningkatan signifikan dalam pemahaman konseptual, koneksi antar konsep, refleksi diri, dan penerapan konsep, yang tercermin dalam nilai rata-rata portofolio di atas 80. Analisis kualitatif mengungkapkan bahwa mahasiswa mampu menjelaskan alasan matematis di balik prosedur, memperbaiki kesalahan konseptual, dan mengaitkan konsep dengan konteks kehidupan nyata. Penelitian ini menegaskan bahwa interaksi sosial dalam kegiatan *peer-review* dan bimbingan dosen berperan penting sebagai *scaffolding* dalam membangun pemahaman matematis mahasiswa.

Kata kunci *Konstruktivisme, Penilaian portofolio, Pemahaman konsep matematis, Refleksi, Pembelajaran matematika*

Abstract This study seeks to analyse the implementation of a constructivist approach through portfolio-based assessment in enhancing students' understanding of mathematical concepts. The research was carried out at a private university in the East Lombok region using a qualitative methodology with a case study design. Data collection techniques included classroom observations, in-depth interviews, and analysis of students' portfolio documents. The findings indicate that the integration of a constructivist framework with portfolio assessment contributes to a transformation in the learning paradigm, shifting from lecturer-centered instruction toward a more reflective and collaborative learning environment. Students exhibited notable improvement in their conceptual comprehension, ability to establish interconceptual relationships, engagement in self-reflection, and application of mathematical concepts, as evidenced by average portfolio scores exceeding 80. Qualitative analysis further indicates that students were able to articulate the mathematical reasoning underlying procedures, identifying and correcting conceptual misconceptions, and contextualizing abstract concepts within real-life situations. The study also highlights the pivotal role of social interaction during peer-review activities and lecturer facilitation as forms of scaffolding that support the development of students' mathematical understanding.

Keywords *Constructivism, Portfolio assessment, Mathematical conceptual understanding, Reflection, Mathematics learning*

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Introduction

Mathematical conceptual understanding is formed when mathematical ideas, procedures, or facts are interconnected within a coherent network of knowledge (Kesumawati, 2008). The ability to understand mathematical concepts serves as a fundamental basis for the development of other mathematical skills and contributes to the formation of scientific character, such as logical, critical, and creative thinking abilities (Khoerunnisa & Hidayati, 2022).

Theoretically, deep mathematical conceptual understanding constitutes a crucial foundation for university students, particularly prospective teachers, to effectively teach mathematics. Constructivist learning theory, pioneered by Piaget and Vygotsky, emphasizes that knowledge is not passively transmitted from teacher to student but is actively constructed by learners through interaction with their environment and cognitive processing of information (Azzahra et al., 2025; Vygotsky, 1978). In the context of mathematics, conceptual understanding goes beyond memorizing definitions or formulas; it involves comprehending the meaning underlying symbols, procedures, and relationships among mathematical objects. Constructivist approaches argue that the most effective learning occurs when students are actively engaged in exploration, discovery, and meaning-making, which are subsequently consolidated through reflection and elaboration (Brooks & Brooks, 1999).

Numerous studies have highlighted the importance of student-centered pedagogical approaches in enhancing mathematical conceptual understanding. (Birgin & Baki, 2007; Tiwari & Tang, 2003) in a meta-analysis, found a significant positive impact of portfolio assessment and constructivist learning environments in general on university students' conceptual understanding. Similarly, Lee and Chen (2021) reported that constructivist learning environments improved students' problem-solving skills in calculus, where effective problem solving is highly dependent on conceptual understanding. Garcia and Rodriguez (2020) also emphasized the critical role of reflection in developing conceptual understanding through the use of reflective journals. Collectively, these studies support constructivist principles and underscore the importance of authentic assessment methods.

Low levels of mathematical conceptual understanding among university students, particularly in teacher education programs, remain a persistent challenge within Indonesia's higher education system. Preliminary observations of students in the Primary School Teacher Education Program at Sekolah Tinggi Agama Islam (STAI) Darul Kamal NW, East Lombok, indicate a tendency for students to rely on rote memorization of formulas without understanding their intrinsic meaning or the interconnections among concepts, especially in Algebra and Geometry topics within the Mathematics Studies course. This phenomenon aligns with findings from previous studies showing that many students struggle to integrate procedural and conceptual knowledge, resulting in difficulties applying mathematical concepts in broader contexts or solving complex problems (Fauziyah & Hakim, 2025; Hamid, 2025). Graduates of teacher education programs who lack deep mathematical conceptual understanding are likely to face challenges in delivering high-quality instruction in the future, particularly in fostering students' mathematical understanding at lower educational levels.

Preliminary observations of students in the Primary Madrasah Teacher Education Program at STAI Darul Kamal NW, East Lombok region, indicate that students' mathematical conceptual understanding in mathematics courses particularly in Algebra and Geometry remains low. Students tend to rely on rote memorization of formulas without comprehending their underlying meanings or the interrelationships among concepts, which results in

difficulties integrating conceptual and procedural understanding when solving mathematical problems. This condition highlights the need for instructional approaches that enable students to actively construct their knowledge. Accordingly, this study adopts a constructivist approach through portfolio assessment within a qualitative case study design to examine in depth the process of enhancing students' mathematical conceptual understanding through reflective and sustained tasks that emphasize active learning, reflection, and social interaction (Supardan, 2016).

Portfolio assessment was initially adopted as an evaluation instrument that allows educators to assess both learning processes and outcomes comprehensively (Anugraheni, 2017). A portfolio is a collection of evidence demonstrating academic development, competency achievement, and learning attitudes. Previous research indicates that portfolio assessment facilitates student self-reflection while enabling educators to monitor students' conceptual development more effectively (Patni et al., 2019). In addition, portfolios enhance assessment objectivity, increase learning motivation, foster self-confidence, and strengthen lecturer–student interactions (Sukanti, 2010).

Students often experience difficulties in understanding abstract mathematical concepts because instruction tends to be oriented toward final outcomes. Through portfolios containing collections of assignments, student responses, observation notes, interviews, activity reports, and reflective journals, students are provided with opportunities to develop mathematical understanding gradually and continuously (Paulson et al., 1991; Sembiring & Sari, 2022). Portfolio assessment itself involves evaluating systematically organized collections of student work used to monitor the development of knowledge, skills, and attitudes over a specified period (Marzuki, 2023). Previous studies have shown that portfolio use can improve attendance, participation, and student engagement in the learning process (Akramunnisa, 2021).

International findings further reinforce the effectiveness of portfolio assessment. Research by (Chionidou-Moskofoglou et al., 2021) demonstrated that e-portfolios improved mathematics achievement based on international assessments (PISA and TIMSS), strengthened formative assessment practices, and enhanced self-evaluation skills and metacognitive awareness. Similarly Anggreni and Agustika (2020) found that integrating Problem-Based Learning (PBL) with portfolio assessment enhanced mathematical abilities at the elementary school level. These findings highlight the relevance of portfolio assessment as an effective constructivist strategy.

However, most previous studies have focused on primary and secondary education or employed quantitative approaches emphasizing final outcomes, leaving reflective, affective, and psychomotor aspects, as well as the dynamics of knowledge construction in higher education mathematics—particularly in Measurement and Geometry—relatively underexplored (Arifin, 2012; Nitko & Brookhart, 2014; Supardan, 2016; Suryadi, 2019). Although prior research demonstrates the positive effects of constructivist approaches and portfolio assessment, a gap remains in understanding how these elements can be synergistically optimized to specifically enhance mathematical conceptual understanding. This gap suggests limited exploration of how key stages of constructivist learning—exploration, active engagement, reflection, and elaboration—are integrated into portfolio design, artifact collection, and assessment processes (Birgin & Baki, 2007). While Lee and Chen (2021) focused on constructivist environments and problem solving, they did not explicitly link

portfolio assessment as a primary instrument for measuring conceptual understanding. Likewise, Garcia and Rodriguez (2020) emphasized reflection but focused mainly on journals, which may not capture the comprehensive scope of portfolios containing diverse artifacts that represent students' conceptual development. These gaps indicate the need for more focused research on implementing portfolio assessment within a constructivist framework to target mathematical conceptual understanding more explicitly.

Addressing this gap, the present study proposes a constructivist approach systematically integrated with portfolio assessment as a strategy to enhance students' mathematical conceptual understanding. As an authentic assessment method, portfolio assessment aligns closely with constructivist principles by enabling students to collect, reflect upon, and present evidence of their learning progress, including their thinking processes and deep conceptual understanding (Rust, 2002). Through portfolios, students can document their efforts to construct understanding, such as exploration notes, revised problem solutions, and written reflections on mathematical concepts. This implementation is expected to encourage students to actively engage in their learning rather than passively receive information, thereby fostering more robust and meaningful conceptual understanding.

The urgency of this study lies in addressing the problem of low mathematical conceptual understanding, which hinders students in teacher education programs from preparing to become competent educators. By focusing on a constructivist approach operationalized through portfolio assessment, this study contributes theoretically to the development of more effective instructional and assessment models in mathematics education and provides practical guidance for lecturers in designing courses and assessments that promote deep conceptual understanding. The findings are expected to enhance the quality of mathematics learning in higher education, ultimately contributing to improved mathematics education quality at lower levels, in line with the national goal of advancing education as mandated by the Indonesian National Education System Act (Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 Tentang Sistem Pendidikan Nasional, 2023).

Current instructional practices remain dominated by direct content delivery and conventional assessments limited to final products, providing students with limited opportunities to independently construct conceptual understanding, connect abstract concepts to real-world contexts, and engage in systematic self-reflection. Furthermore, students are not yet accustomed to producing authentic evidence that reflects step-by-step mathematical thinking processes, while lecturers face challenges in designing comprehensive portfolios due to time constraints and administrative workload. These conditions reveal a gap between constructivist principles and the practical implementation of portfolio assessment as an effective learning instrument. Based on this gap, the present study examines the implementation of a constructivist approach through portfolio assessment with the aim of exploring improvements in mathematical conceptual understanding, reflective processes, and the development of students' attitudes and skills that have not been comprehensively documented to date.

Theoretical review

Learning is a series of activities deliberately designed by educators to facilitate changes in learners' attitudes and behaviors toward more constructive directions (Munir & Sholehah, 2022). From a constructivist perspective, learning is understood as an active process in which

learners independently construct knowledge through direct experiences and social interactions, both in individual and collaborative contexts. Constructivism asserts that knowledge cannot be directly transmitted from teachers to learners; rather, meaning is constructed through the internalization of learning experiences (Azizah et al., 2024; Bada & Olusegun, 2015). Consequently, understandings of learning must be learner-centered, and no knowledge exists independently of the meaning assigned by individuals or learning communities. In line with the theories of Piaget and Vygotsky, the processes of assimilation and accommodation serve as fundamental mechanisms in the formation of learners' cognitive structures (Astiti et al., 2024).

Constructivism is one of the major approaches derived from cognitive learning theory. The primary objective of employing a constructivist approach in instruction is to enhance learners' understanding of subject matter content (Pribadi, 2009). Constructivism is regarded as an alternative instructional model capable of addressing the limitations of behaviorist perspectives (Masgumelar & Mustafa, 2021). This is further evidenced by the fact that constructivist implementation gives rise to student-centered learning (SCL), an instructional approach that places learners at the core of the learning process (Dhani et al., 2022; Trinova, 2013).

Constructivist theory emphasizes self-directed learning. In instructional practice, constructivist learning involves connecting learners' prior knowledge with new information. The constructivist learning process generally consists of the following stages: (1) orientation, which provides learners with opportunities to attend to the learning topic and develop motivation; (2) elicitation, which helps learners uncover their existing ideas by allowing them to discuss or present their prior knowledge through posters or written presentations shared with the class; (3) reconstruction of ideas, during which learners clarify their ideas by comparing them with those of peers through discussion; (4) application of ideas, where newly constructed knowledge is applied across various situations to enrich and refine understanding; and (5) review, in which learners apply their knowledge to real-life contexts and revise their ideas by adding information or modifying them to achieve more comprehensive understanding (Suoth et al., 2022).

In Indonesia, the use of portfolio assessment has become an integral component of the Merdeka Curriculum, as outlined in the Assessment Guidelines issued by the Ministry of Education and Culture. These guidelines define portfolio assessment as a continuous evaluation process based on a collection of data or evidence documenting learners' skill development over a certain period (Kemendikbud, 2022). Accordingly, portfolio assessment serves as an alternative to conventional assessments that typically focus solely on cognitive outcomes. This form of assessment also encompasses psychomotor and affective domains, which aligns with the fundamental objectives of Islamic education.

Portfolio assessment is an effective method for comprehensively evaluating learners' academic development. It enables assessment of learning outcomes across cognitive, affective, and psychomotor dimensions (Attorsusi et al., 2024). Moreover, portfolio assessment can enhance learners' (students') engagement in the learning process. Portfolios provide a holistic view of learners' skills and growth throughout the learning experience (Zalukhu et al., 2023). Compared to other assessment methods, portfolio assessment more accurately reflects learners' competencies and skill development (Krall, 2023).

Concept mastery is one of the essential competencies targeted in mathematics learning. This ability includes demonstrating understanding of learned mathematical concepts,

explaining the relationships among concepts, and applying concepts or algorithms accurately, efficiently, flexibly, and appropriately to solve problems (Kesumawati, 2008). Mathematical conceptual understanding is a fundamental competency that should be acquired by every individual, as it serves as a critical foundation for solving mathematical tasks and problems (Khoerunnisa & Hidayati, 2022).

In mathematics education, two types of understanding are commonly discussed: instrumental understanding and relational understanding. Instrumental understanding refers to learners' ability to memorize concepts or rules in isolation, apply formulas to routine problems, and complete tasks based on predetermined procedures. At this level, learners follow steps without comprehending the deeper meaning of the concepts involved. In contrast, relational understanding reflects learners' ability to logically connect one concept to another and to be aware of the reasoning processes employed. A learner is considered to possess strong understanding when they can explain the interrelationships among concepts and comprehend each step required to solve mathematical problems (Saputra, 2022).

Within this context, portfolio assessment serves as a highly effective tool because it allows lecturers to examine concrete evidence of students' conceptual development. Rather than relying solely on a single final test score, portfolios enable the evaluation of conceptual growth over time. For example, students may include in their portfolios: (1) initial exploration notes of a new concept, (2) self-developed problem solutions applying the concept, (3) written reflections explaining their evolving understanding, including challenges encountered and strategies used to overcome them, and (4) comparisons of different solutions to the same problem that demonstrate relational understanding. Through the collection of such artifacts, lecturers can identify misconceptions and guide students toward deeper relational understanding (Skemp, 1976).

This interconnection illustrates how constructivist approaches facilitate knowledge construction, while portfolio assessment provides authentic evidence of that knowledge and supports further reflection. The theoretical implications for instructional practice are substantial: lecturers can design more student-centered learning environments, promote active exploration, and utilize portfolios as powerful diagnostic and formative tools to monitor and support the development of students' deep mathematical conceptual understanding.

Methods

This study employed a qualitative approach using a case study design, as it focused on an in-depth exploration of the implementation of a constructivist approach through portfolio assessment in enhancing students' mathematical conceptual understanding. A case study design allows the researcher to gain a contextualized understanding of classroom learning processes and to examine changes in students' conceptual understanding over time.

The study was conducted at Sekolah Tinggi Agama Islam Darul Kamal NW Kembang Kerang, East Lombok Region, within the Mathematics Studies for Elementary School course offered in the third semester. The research participants consisted of students enrolled in the course, as well as the course lecturer, who served as a facilitator of constructivist learning. The research was carried out in several stages: (i) *preparation* which involves the development of instructional materials and portfolio instruments grounded in constructivist principles; (ii) *implementation*, i.e., conducting constructivist-based learning activities in which students

actively constructed conceptual understanding through exploration and reflective activities documented in their portfolios; and (iii) *evaluation* by analyzing the improvement of students' conceptual understanding based on portfolio artifacts, interviews, and classroom observations.

The portfolio employed in this study was a "process portfolio," defined as a collection of documents that demonstrate students' conceptual development over the course of one semester. The portfolio components included: individual and group assignments, self-reflective notes on learning difficulties and progress, revised assignments based on lecturer feedback, records of conceptual error analysis, and student-constructed summaries of mathematical concepts.

Within the constructivist learning framework, the portfolio functioned as a medium through which students independently constructed and reflected upon their knowledge. Students were required to document their thinking processes, explain problem-solving strategies, and identify changes in understanding across successive tasks. The lecturer acted as a facilitator, providing scaffolding through reflective discussions and peer-review activities to strengthen social interaction in the knowledge construction process.

Research data were collected using three primary techniques: documentation, observation, and interviews. Documentation involved content analysis of students' portfolios to identify the development of mathematical conceptual understanding. The classroom observations were conducted to assess student engagement, the lecturer's implementation of constructivist strategies, and the dynamics of classroom discussions. Structured and in-depth interviews were used to explore students' reflective experiences related to the learning process and the role of portfolios in supporting their understanding of mathematical concepts.

The research instruments included observation guidelines, interview protocols, and a portfolio assessment rubric. The portfolio rubric was developed based on four main dimensions: (1) conceptual understanding, (2) representational ability and inter-concept connections, (3) the ability to apply concepts in novel contexts, and (4) self-reflection on the learning process.

The rubric and instrument guidelines were validated through expert judgment by two mathematics education lecturers to ensure alignment with the research objectives. Data analysis was conducted using descriptive qualitative techniques following the stages of case study analysis (Fiantika et al., 2022). Finally, improvements in students' mathematical conceptual understanding were identified through changes in portfolio content and interview data indicating a shift from predominantly procedural understanding toward deeper conceptual understanding

Findings

Overview of the implementation of portfolio-based constructivist approach

The findings of this study indicate that the implementation of a constructivist approach through portfolio-based assessment had a positive impact on both the learning process and student learning outcomes. Based on classroom observations and analysis of portfolio documents, the learning process became more active, collaborative, and reflective. Students demonstrated high levels of enthusiasm in completing assignments, revising errors, and discussing mathematical concepts they had not yet fully understood.

Significant changes were observed in classroom dynamics. At the beginning of the course, students tended to be passive and highly dependent on the lecturer’s explanations. However, following the implementation of this approach, students gradually began to construct their own understanding through exploration, discussion, and reflection. The lecturer assumed the role of a facilitator by providing scaffolding through open-ended questions and formative feedback. Students came to realize that learning mathematics is not merely about memorizing formulas, but about understanding the meaning underlying mathematical procedures. This process reflects a shift from teacher-centered learning to student-centered learning, consistent with constructivist principles emphasizing that knowledge is constructed through experience and social interaction.

Structure and function of the portfolio in learning

The portfolio-based assessment applied in this study was designed as a process portfolio, serving as an assessment instrument that continuously evaluates students’ conceptual development. The portfolio consisted of four main components: daily assignments and quizzes and practical tasks, the Mid-Semester Examination (MSE), the Final Semester Examination (FSE), and individual reflections.

Each component served a complementary function. Daily assignments were used to monitor students’ conceptual development formatively, while the MSE and FSE assessed students’ integrative ability to connect various mathematical concepts. The individual reflection component provided students with an opportunity to document their learning experiences, challenges encountered, and strategies used to understand mathematical concepts. In summary, the portfolio structure demonstrated a cyclical and reflective learning process.

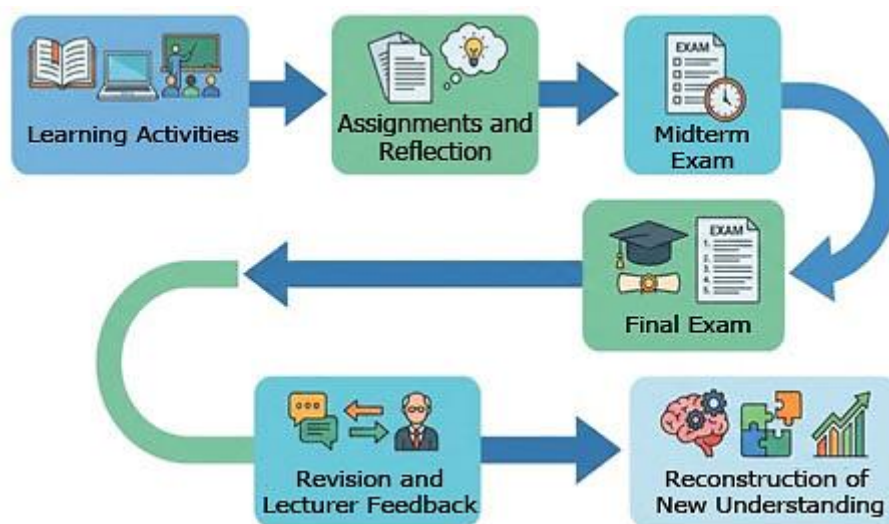


Figure 1. Portfolio assessment structure

The cyclical model illustrated in Figure 1 indicates that portfolio assessment is not only summative in nature, but also transformational, encouraging students to continuously refine their thinking through reflection on errors and feedback received.

Development of students' conceptual understanding

Content analysis of student portfolios revealed a clear progression in students' mathematical conceptual understanding. At the initial stage of learning, most students were only able to present procedural formulas without explaining the conceptual meaning underlying them. For example, on the topic of the area of a rectangle, one student wrote: Area = length \times width. If the length is 20 cm and the width is 15 cm, then the area is 30 cm².

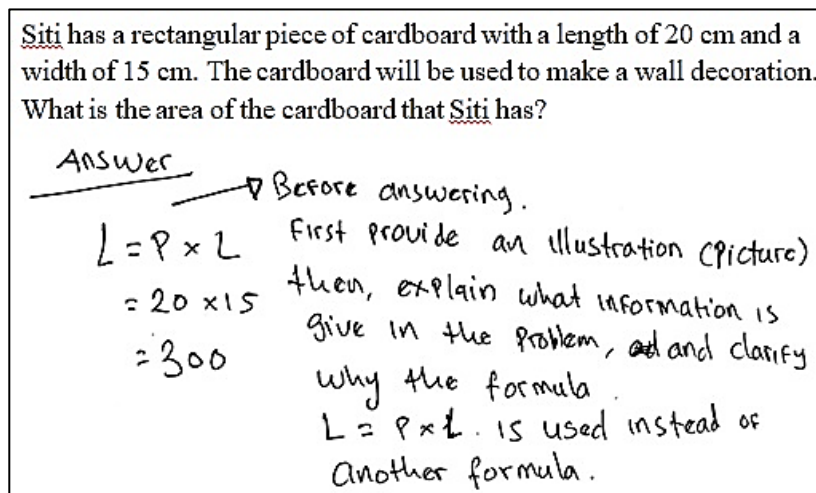


Figure 2. Example of a student's initial response

In Figure 2, the student merely stated the formula $L = p \times l$ without providing a conceptual explanation of why the formula applies. The lecturer provided corrective feedback, such as “Explain the origin of the formula based on unit squares,” to prompt conceptual reflection. Following this feedback, students began to explain area as the number of unit squares covering a region and included visual representations in their assignments.

By mid-semester, students demonstrated the ability to connect concepts, such as relating area to volume and measurement units. Group discussions became more dynamic, with students actively exchanging ideas and articulating the reasoning behind their solution strategies. By the end of the semester, most students were able to explain concepts both verbally and symbolically and to produce reflective writings indicating metacognitive awareness.

These developments were also reflected in the portfolio assessment rubric analysis. Students showed improved ability to articulate conceptual relationships, including connections among area, volume, and measurement units. Portfolio results indicated enhanced quality of mathematical representations and more coherent verbal explanations.

Table 1. Portfolio assessment results

Assessment aspect	Initial average	Final average	Improvement
Conceptual understanding	2.7	3.6	+0.9
Conceptual connections	2.4	3.5	+1.1
Self-reflection	2.3	3.7	+1.4
Application of concepts	2.8	3.8	+1.0

Table 1 shows that the mean score for conceptual understanding increased from 2.7 to 3.6; conceptual connections from 2.4 to 3.5; self-reflection from 2.3 to 3.7; and application of concepts from 2.8 to 3.8. These results indicate a substantial and consistent improvement in students' conceptual understanding and reflective thinking abilities.

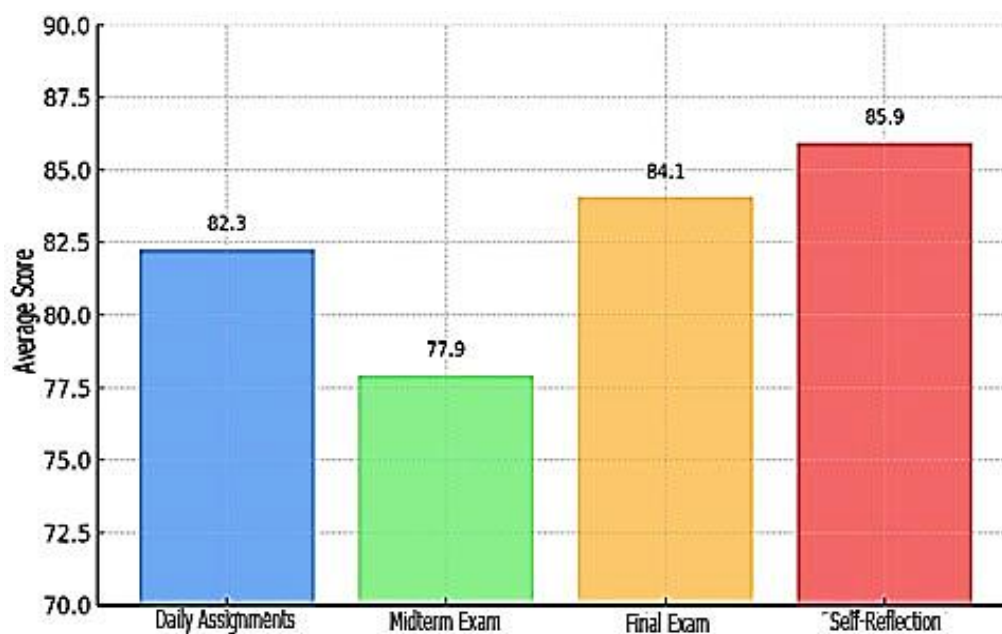


Figure 3. Distribution of students' portfolio scores

Quantitative analysis of assessment results (Figure 3) revealed a consistent upward trend across all portfolio components. Data from fifteen students showed average scores of 82.3 for daily assignments, 77.9 for the mid-semester examination, 84.1 for the final examination, and 85.9 for self-reflection. This pattern suggests gradual improvement throughout the semester.

The relatively lower mid-semester examination scores indicate that students were still in the early stages of assimilating new concepts at that point. In contrast, higher scores on the final examination and reflective components indicate successful accommodation of deeper conceptual understanding following cycles of reflection, feedback, and task revision embedded in the portfolio process.

The average score graph (Figure 3) shows that self-reflection achieved the highest score among all components. This finding suggests that the learning process enhanced not only students' cognitive abilities but also their metacognitive awareness and self-evaluation skills. Students became more capable of identifying strengths and weaknesses in their mathematical thinking and demonstrated greater maturity in reconstructing concepts. The consistent improvement between formative (daily assignments) and summative (final examination) components indicates continuity between learning processes and outcomes. Overall, these quantitative findings reinforce the qualitative evidence that the implementation of a constructivist approach through portfolio-based assessment significantly improved the quality of mathematics learning, particularly in terms of conceptual understanding and reflective capacity.

Reflective and social dimensions of learning

The constructivist approach implemented through portfolio-based assessment in this study not only transformed how students understood mathematical concepts but also reshaped how they perceived the learning process itself. Reflection emerged as a central component, guiding students to view errors as an integral part of thinking rather than as failures.

Through task revision and reflective writing at the end of each learning cycle, students learned to revisit their thinking processes, including how they formulated problem-solving strategies, why errors occurred, and how those errors could be corrected. These activities strengthened students' metacognitive abilities specifically, their awareness of how they think, learn, and regulate their cognitive strategies.

Each student was required to include reflective notes at the end of the portfolio, documenting learning experiences, challenges encountered, responses to lecturer feedback, and strategies used to address conceptual difficulties. Document analysis revealed a shift from descriptive reflections to analytical ones. At the beginning of the semester, students tended to write factual statements such as "I find it difficult to understand volume problems because there are many formulas." By the end of the semester, these reflections evolved into analytical statements such as "My difficulty with volume concepts was due to my limited understanding of the relationship between base area and height in forming three-dimensional space."

This shift indicates the development of higher-order thinking skills resulting from repeated reflective processes. The lecturer provided not only grades but also formative feedback in the form of open-ended questions, such as "Why did you choose this approach?" or "How do you know your solution is correct?" These questions encouraged students to think more deeply about the rationale underlying their mathematical procedures.

In addition to the reflective dimension, the learning process also demonstrated growth in the social dimension. Through peer review, group discussions, and portfolio presentations, students learned to collaborate and communicate mathematical ideas openly. They provided feedback on peers' portfolios, compared different modes of reasoning, and explained concepts using their own language.

Classroom observations showed that social dynamics became increasingly participatory. Students who were initially passive gradually became more engaged in discussion and questioning. Such interactions served as a medium for social construction of meaning, aligning with Vygotsky (1978) concept of the zone of proximal development, in which knowledge is constructed through dialogue and scaffolding within the learning environment.

Overall, the reflective and social dimensions embedded in portfolio-based assessment fostered a learning system that promoted metacognitive awareness, learner autonomy, and collaboration. Students became not merely recipients of knowledge, but active constructors of meaning both individually through self-reflection and socially through collaborative learning interactions. These findings are further supported by the interview transcripts as follows.

Interview transcript with student SHH

R : During the process of compiling your portfolio, what did you feel was most different compared to your usual way of learning?

SHH : Usually, I only focus on finding the correct answer. However, in the portfolio, I was required to explain my reasoning. At first, I felt confused, but over time

I realized that understanding the concept is more important than memorizing formulas.

R : Could you explain how you revised your work after receiving feedback from the lecturer?

SHH : The lecturer wrote comments on my assignment, for example, "Try to explain the relationship between rectangles and unit squares." After that, I revisited my notes and drew unit squares on paper to improve my understanding. Then, I revised my assignment and wrote a reflection explaining why my initial answer was incorrect.

R : So, do you feel that the revision process helped you understand the concept better?

SHH : Yes, it helped a lot. I came to understand why my initial approach was incorrect and learned how to correct it independently.

Interview transcript with student AW

R : How about group work and discussions-did they help you understand the concepts?

AW : They were very helpful. When other students explained the material, their explanations were sometimes easier to understand. For example, when discussing the volume of a rectangular prism, one of my classmates said, "Imagine stacking unit cubes up to a certain height." That explanation helped me realize the meaning behind multiplying length, width, and height.

R : Did you also provide feedback to other students?

AW : Yes, we reviewed each other's portfolios. Sometimes I helped classmates who were confused, but I also often learned from how they explained concepts in their writing.

Interview transcript with student SR

R : How do you view the overall learning process using portfolios?

SR : I feel that the process is longer, but much more meaningful. I can see how my understanding changed from week to week. At first, I was afraid of making mistakes, but now I understand that making mistakes is part of learning.

R : Do you think this type of learning can be applied when you become a teacher in the future?

SR : Absolutely. If I become a teacher, I would like my students to have portfolios as well, so they can see their own learning progress.

The interview results indicate that the reflective processes undertaken by students not only improved their conceptual understanding but also fostered greater self-confidence and responsibility for learning. Written reflections and collective discussions encouraged students to construct mathematical understanding through both personal and social experiences simultaneously.

From a social perspective, peer-review interactions and group collaboration functioned as instructional bridges through which students reinforced one another's understanding. In this

context, the lecturer played the role of a facilitator who guided dialogue and ensured that discussions remained productive and oriented toward meaning construction.

Thus, the reflective and social dimensions embedded in portfolio-based assessment contributed to the development of a learning system that promotes metacognitive awareness, learner autonomy, and collaboration. Students were not merely recipients of knowledge, but active constructors of meaning—both individually through self-reflection and socially through collaborative learning interactions. Figure 4 illustrates the reflective and social dimensions observed in this study

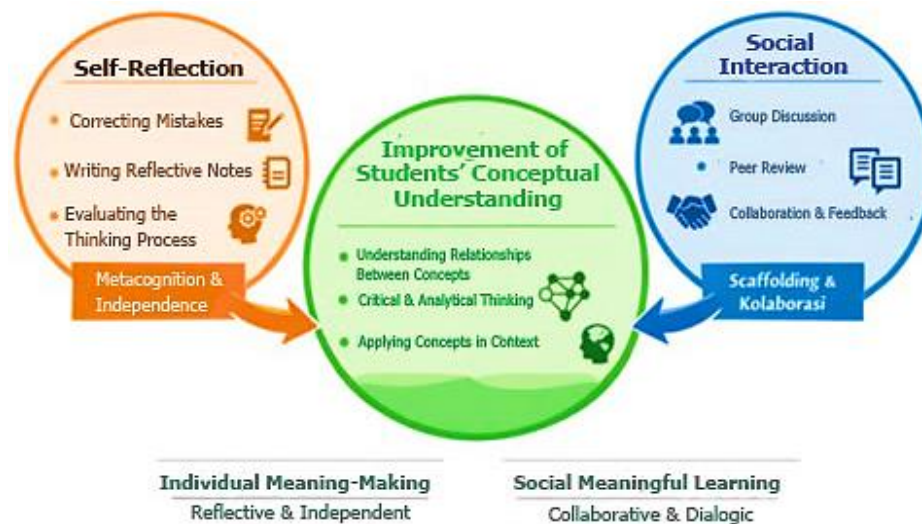


Figure 4. Visualization of reflective and social dimensions in learning

Discussion

The implementation of a constructivist approach through portfolio-based assessment in mathematics learning has created a learning environment that enables students to actively construct their own knowledge. The findings of this study reinforce Piaget’s view that learning occurs through processes of assimilation and accommodation, in which students adapt new information to their existing cognitive structures until a new equilibrium (equilibration) is achieved.

Intensive social interaction during discussions, reflections, and lecturer feedback further strengthens these findings from Vygotsky’s theoretical perspective. In this context, both the lecturer and peers function as sources of scaffolding that support students in progressing from their actual level of competence toward their optimal learning potential within the zone of proximal development (ZPD). Dialogue, argumentation, and collaboration emerge as central mechanisms through which deeper mathematical understanding is constructed.

This study also confirms the findings of Paulson et al. (1991) who argued that portfolios are not merely collections of learning outcomes but records of students’ thinking processes and reflections. In this context, corrective feedback, task revisions, and self-reflections documented in the portfolio serve as evidence of students’ metacognitive development. Students learn to evaluate how they learn, not merely what they learn. Thus, the portfolio functions dually as a

formative assessment tool and a reflective learning instrument that supports intellectual growth.

From a social perspective, this approach promotes collaborative learning that fosters students' self-confidence and mathematical communication skills. Group discussions and peer review strengthen understanding through interaction and clarification of ideas, in line with the principles of social constructivism. This is evident in students' statements indicating that their understanding improved after listening to their peers' explanations. Such interactions demonstrate that knowledge is not constructed individually, but rather emerges through dialogue and negotiation of meaning within a social context.

The observed improvement in conceptual understanding reflected in portfolio outcomes is also consistent with the findings of Patni et al. (2019), who reported that portfolio assessment enhances students' self-reflection skills and learning motivation. These results align with Anggreni and Agustika (2020), who found that the integration of problem-based learning with portfolio assessment strengthens critical thinking and mathematical problem-solving skills. At the international level, Chionidou-Moskofoglou et al. (2021) demonstrated that portfolio use enhances metacognitive awareness and learning outcomes in mathematics education.

Overall, the findings of this study extend empirical evidence that constructivist-based portfolio assessment is not only effective in improving conceptual understanding, but also in developing reflective awareness, collaborative skills, and students' academic responsibility. These results indicate that knowledge construction is optimized when students actively reflect on learning experiences, engage in dialogue with peers, and receive meaningful feedback from lecturers.

In the context of teacher education, this approach has important implications. PGMI students who engage in reflective learning through portfolio assessment not only learn mathematical concepts, but also develop pedagogical competencies to implement similar strategies in their future classroom practices. Thus, a portfolio-based constructivist approach not only enhances students' learning outcomes but also prepares them to become reflective, creative, and adaptive prospective teachers who are responsive to learners' needs.

Conclusion

This study concludes that the implementation of a constructivist approach through portfolio-based assessment has a positive and significant impact on improving students' mathematical conceptual understanding. Through the portfolio, students demonstrate not only learning outcomes but also their thinking processes and the gradual development of understanding over time. This approach creates a reflective learning environment in which errors are viewed as opportunities for constructing new knowledge.

The findings indicate that students are able to shift from procedural understanding toward deeper conceptual understanding. The portfolio serves a dual function as a formative assessment tool and a reflective medium for revising and reconstructing knowledge. Through social interaction in discussions and peer review, students gain collaborative learning experiences that support cognitive development, as described in Vygotsky's theory of the zone of proximal development. In this process, the lecturer acts as a learning facilitator who provides scaffolding through reflective feedback.

The integration of a constructivist approach with portfolio-based assessment successfully fosters students' metacognitive awareness, strengthens critical thinking skills, and cultivates

responsibility for the learning process. Therefore, this strategy is highly relevant for implementation in higher education, particularly in teacher education programs, as it not only enhances mathematical understanding but also shapes the reflective and professional character of prospective educators.

Prospective teacher students are expected to utilize this learning experience to develop reflective and collaborative learning practices in elementary school contexts. Educational institutions are encouraged to support such practices through instructional policies that provide space for continuous formative assessment and reflective feedback.

Nevertheless, this study has limitations related to its relatively small sample size and specific context, involving students from a single study program over one semester. Individual factors such as learning styles, motivation, and prior learning experiences were not examined in depth. Future research is recommended to expand the research context, employ mixed-methods approaches, and explore the long-term impact of portfolio-based assessment on the development of pedagogical and professional competencies among prospective teachers.

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References

- Akramunnisa, A. (2021). Implementasi penilaian portofolio untuk meningkatkan hasil belajar mahasiswa teknik informatika mata kuliah riset operasi. *Jurnal Pendidikan dan Pembelajaran*, 1(2), 95–100. <https://doi.org/10.62388/jpdp.v1i2.15>
- Anggreni, N. W. Y., & Agustika, G. N. S. (2020). Model pembelajaran problem-based learning berbasis penilaian portofolio terhadap kompetensi pengetahuan matematika. *Jurnal Ilmiah Pendidikan Profesi Guru*, 3(1), 61–72. <https://doi.org/10.23887/jippg.v3i1.26814>
- Anugraheni, I. (2017). Penggunaan portofolio dalam perkuliahan penilaian pembelajaran. *Jurnal Pendidikan Dasar Perkhasa*, 3(1), 246–258.
- Arifin, Z. (2012). *Evaluasi pembelajaran*. PT Remaja Rosdakarya.
- Astiti, K. A., Yanti, B. A. S., Suryaningsih, N. M. A., Poerwati, C. E., Zahara, L., & Wijaya, I. K. W. B. (2024). *Teori psikologi konstruktivisme*. Nilacakra.
- Attorsusi, S. M., Mahpudin, M., Ahmad, J., & Mutaqin, D. Z. (2024). Implementasi penilaian portofolio pada pendidikan agama Islam di sekolah dasar karakter Al-Adzkiya Cianjur. *Jurnal PAI Raden Fatah*, 6(1), 336–344.
- Azizah, S. L., Hardaningtyas, K., Pratama, Z. A., & Moewardi, I. (2024). Penerapan teori belajar konstruktivisme dalam meningkatkan keaktifan dan hasil belajar siswa. *DIAJAR: Jurnal Pendidikan dan Pembelajaran*, 3(1), 36–42. <https://doi.org/10.54259/diajar.v3i1.2233>
- Azzahra, N. T., Ali, S. N. L., & Bakar, M. Y. A. (2025). Teori konstruktivisme dalam dunia pembelajaran. *Jurnal Ilmiah Research Student*, 2(2), 64–75. <https://doi.org/10.61722/jirs.v2i2.4762>
- Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education*, 5(6), 66–70.
- Birgin, O., & Baki, A. (2007). The use of portfolio to assess students' performance. *Educational Research Review*, 4(2), 75–90.
- Brooks, J. G., & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms*. ASCD.
- Chionidou-Moskofoglou, M., Doukakis, S., & Lappa, A. (2021). The use of e-portfolios in teaching and assessment. *arXiv*. <https://arxiv.org/abs/2105.15114>

- Dhani, M. I., Aziz, T. A., & Hakim, L. E. (2022). Pembelajaran matematika melalui pendekatan konstruktivisme. *Jurnal Pendidikan MIPA*, 12(4), 1236–1241. <https://doi.org/10.37630/jpm.v12i4.796>
- Fauziyah, N., & Hakim, L. E. (2025). Analysis of students' mathematics conceptual understanding based on differences in mathematics thinking styles. *Jurnal Pendidikan MIPA*, 26(2), 941–970. <https://doi.org/10.23960/jpmipa.v26i2.pp941-970>
- Fiantika, F. R., Wasil, M., Jumiyati, S. R. I., Honesti, L., Wahyuni, S. R. I., Mouw, E., Mashudi, I., Hasanah, N. U. R., Maharani, A., & Ambarwati, K. (2022). *Metodologi penelitian kualitatif*. PT Global Eksekutif Teknologi.
- Garcia, M., & Rodriguez, A. (2020). Developing conceptual understanding in undergraduate mathematics through reflective journals. *Journal of College Mathematics Instruction*, 18(4), 311–328.
- Hamid, A. (2025). Analisis faktor penyebab miskonsepsi mahasiswa pada materi aljabar: Perspektif kognitif dan pedagogis. *Venn: Journal of Sustainable Innovation on Education, Mathematics and Natural Sciences*, 4(2), 71–80. <https://doi.org/10.53696/venn.v4i2.264>
- Kemendikbud. (2022). *Panduan penilaian dalam Kurikulum Merdeka*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.
- Kesumawati, N. (2008). Pemahaman konsep matematik dalam pembelajaran matematika. Dalam *Seminar Nasional Matematika dan Pendidikan Matematika* (Vol. 2, hlm. 231–234).
- Khoerunnisa, A., & Hidayati, N. (2022). Analisis kemampuan pemahaman matematis. *PHI: Jurnal Pendidikan Matematika*, 6(1), 1–10. <https://doi.org/10.33087/phi.v6i1.180>
- Krall, G. (2023). Teacher-designed mathematical portfolio assessments: Motivations, potential benefits, and lessons learned. *Canadian Journal of Science, Mathematics and Technology Education*, 23(2), 303–321. <https://doi.org/10.1007/s42330-023-00280-3>
- Lee, K., & Chen, Y. (2021). Constructivist learning environments and their effect on students' problem-solving skills in calculus. *International Journal of Mathematics Education*, 43(1), 55–72.
- Marzuki, I. (2023). Urgensi penilaian portofolio dalam evaluasi pembelajaran di era society 5.0. *Tadarus Tarbawy: Jurnal Kajian Islam dan Pendidikan*, 5(2). <https://doi.org/10.31000/jkip.v5i2.10073>
- Masgumelar, N. K., & Mustafa, P. S. (2021). Teori belajar konstruktivisme dan implikasinya dalam pendidikan dan pembelajaran. *GHAITSA: Islamic Education Journal*, 2(1), 49–57. <https://doi.org/10.62159/ghaitsa.v2i1.188>
- Munir, M., & Sholehah, H. (2022). Penerapan metode demonstrasi untuk meningkatkan hasil belajar pada mata pelajaran IPA sekolah dasar. *Jurnal Al Muta'aliyah*, 2(2), 28–32. <https://doi.org/10.51700/almutaliyah.v2i2.359>
- Nitko, A. J., & Brookhart, S. M. (2014). *Educational assessment of students*. Pearson Education.
- Patni, L. D. P., Parwati, N. N., & Suharta, I. G. P. (2019). Peningkatan pemahaman konsep matematika siswa melalui penerapan model pembelajaran AIR disertai penilaian portofolio. *Jurnal Pendidikan dan Pembelajaran Matematika Indonesia*, 7(1), 22–32. <https://doi.org/10.23887/jppm.v7i1.2810>
- Paulson, F. L., Paulson, P. R., & Meyer, C. A. (1991). What makes a portfolio? *Educational Leadership*, 48(5), 60–63.
- Pribadi, B. A. (2009). Pendekatan konstruktivis dalam kegiatan pembelajaran. Makalah seminar SEAMOLEC.
- Rust, F. (2002). The idea of the portfolio. Dalam N. L. Webb (Ed.), *Teaching and learning in the middle grades*. Allyn & Bacon.
- Saputra, H. (2022). *Kemampuan pemahaman matematis*. <https://www.researchgate.net>
- Sembiring, R. K. B., & Sari, A. S. P. (2022). Analisis kemampuan pemahaman matematika berbasis penilaian portofolio. *Cartesius: Jurnal Pendidikan Matematika*, 5(1), 59–64. <https://ejournal.ust.ac.id/index.php/CARTESIUS/article/view/2078>
- Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77, 20–26.
- Sukanti, S. (2010). Pemanfaatan penilaian portofolio dalam meningkatkan hasil belajar akuntansi. *Jurnal Pendidikan Akuntansi Indonesia*, 8(2). <https://doi.org/10.21831/jpai.v8i2.952>
- Suoth, L., Mutji, E. J., & Balamu, R. (2022). Penerapan pendekatan konstruktivisme Vygotsky terhadap pembelajaran bahasa Indonesia. *Journal for Lesson and Learning Studies*, 5(1), 48–53. <https://doi.org/10.23887/jlls.v5i1.40510>

- Supardan, H. D. (2016). Teori dan praktik pendekatan konstruktivisme dalam pembelajaran. *Edunomic: Jurnal Pendidikan Ekonomi*, 4(1).
- Suryadi, D. (2019). Penerapan pembelajaran konstruktivistik untuk meningkatkan pemahaman konsep matematis mahasiswa. *Jurnal Pendidikan Matematika*, 13(2), 123–134.
- Tiwari, A., & Tang, C. (2003). From process to outcome: The effect of portfolio assessment on student learning. *Nurse Education Today*, 23(4), 269–277. [https://doi.org/10.1016/S0260-6917\(03\)00012-1](https://doi.org/10.1016/S0260-6917(03)00012-1)
- Trinova, Z. (2013). Pembelajaran berbasis student-centered learning pada materi pendidikan agama Islam. *Al-Ta'lim Journal*, 20(1), 324–335. <https://doi.org/10.15548/jt.v20i1.28>
- Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional. (2003).
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Zalukhu, H., Naibaho, T., & Simanjuntak, R. M. (2023). Evaluasi dan penilaian pada pembelajaran matematika. *Journal on Education*, 6(1), 4781–4792. <https://doi.org/10.31004/joe.v6i1.3634>