

DEVELOPMENT OF MOODLE-ASSISTED STAD COOPERATIVE LEARNING MODEL TO IMPROVE STUDENTS' CONCEPTUAL UNDERSTANDING AND SELF-REGULATED LEARNING ON ELEMENTARY SCHOOL

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ARTICLE INFO

Article history:

Received Feb 28, 2026

Revised Mar 09, 2026

Accepted Apr 15, 2026

Keywords:

Conceptual Understanding
Self-Regulated Learning
Cooperative Learning
Model
Moodle
STAD

ABSTRACT

Conceptual understanding of fractions among elementary school students remains relatively low, and many learning practices still rely on conventional teaching methods that do not fully support digital learning environments. In addition, students self-regulated learning skills are often not optimally developed in mathematics learning. This study aims to develop a Student Teams Achievement Division (STAD) cooperative learning model supported by the Moodle Learning Management System (LMS) (STAD–Moodle) to improve students conceptual understanding of fractions and self-regulated learning. This research employed a Research and Development (R&D) method using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The research subjects were fifth-grade elementary school students selected through purposive sampling. Data were collected using conceptual understanding tests, self-regulated learning questionnaires, observation sheets, and interview guidelines. The developed model was validated by subject matter experts, media experts, and learning experts to determine its validity and feasibility. The effectiveness of the model was analyzed using the N-gain test to measure the improvement in students learning outcomes. The results indicated that the developed STAD–Moodle model achieved a high level of validity based on expert evaluations. The implementation results showed that the integration of Moodle features facilitated concept exploration, collaborative discussion, and digital assessment with immediate feedback. The effectiveness test revealed an increase in conceptual understanding with an N-gain of 67% and an increase in students self-regulated learning of 66%, both categorized as medium–high improvement. It can be concluded that the STAD–Moodle model is a valid, practical, and effective digital learning innovation for improving students conceptual understanding of fractions and strengthening self-regulated learning in elementary mathematics learning.

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How to Cite:

Suryadi, M., Rohaeti, E.E., & Samsudin, A. (2026). Development of Moodle-Assisted STAD Cooperative Learning Model to Improve Students' Conceptual Understanding and Self-Regulated Learning on Elementary School. *JIML*, 9(3), 528-539.

INTRODUCTION

Conceptual understanding is a fundamental component of mathematics education in primary schools, as it enables students to comprehend relationships between mathematical concepts, apply knowledge in various contexts, and solve problems meaningfully. In particular, understanding fractions requires students to integrate numerical relationships, symbolic representations, and real-life applications. However, many students experience difficulties in developing conceptual understanding of fractions, which subsequently affects their overall mathematics achievement (Assyifa et al., 2023; Mahadi et al., 2023). Therefore, strengthening conceptual understanding is essential for improving the quality of mathematics learning at the primary level.

In addition to conceptual understanding, self-regulated learning plays a crucial role in students learning success. Self-regulated learning refers to students ability to plan, monitor, and evaluate their own learning processes. Students with strong self-regulation tend to demonstrate better persistence, deeper engagement, and more effective learning strategies, which contribute to higher conceptual understanding. Previous studies have shown that students who actively regulate their learning are more capable of constructing mathematical concepts independently and overcoming misconceptions (Hidayah et al., 2024; Hartono et al., 2025). Thus, conceptual understanding and self-regulated learning are closely interconnected and mutually reinforcing in mathematics education.

Despite their importance, recent studies (2021–2026) indicate that primary school students still demonstrate low levels of conceptual understanding and self-regulated learning. Research by Assyifa et al. (2023) and Mahadi et al. (2023) found that students often experience misconceptions in fraction concepts, particularly in understanding part-whole relationships and equivalent fractions. Furthermore, studies by Hidayah et al. (2024) and Hartono et al. (2025) revealed that students self-regulated learning remains underdeveloped due to teacher-centered instructional practices, limited opportunities for active learning, and insufficient integration of digital learning technologies. These challenges indicate the need for innovative learning models that can simultaneously improve conceptual understanding and foster students learning independence.

One of the learning models that has been widely recognized as effective in addressing these challenges is the Student Teams Achievement Division (STAD) cooperative learning model. STAD promotes collaborative learning through heterogeneous group discussions, peer tutoring, and shared responsibility for learning outcomes. Previous studies have shown that STAD significantly improves students academic achievement, motivation, and conceptual understanding in mathematics (Slavin, 2014; Sari et al., 2019; Shofiatin et al., 2024). A meta-analysis by Permatasari et al. (2023) also confirmed that STAD is effective in enhancing conceptual understanding across different educational levels. These findings suggest that cooperative learning approaches are relevant for addressing students conceptual difficulties.

However, the implementation of STAD in its conventional form still faces several limitations. Studies have reported that traditional STAD tends to be dominated by teachers in the initial stages, lacks structured discussion processes, and relies heavily on individual quizzes as the primary evaluation method (Huda, 2013; Nasution et al., 2024). In addition, the lack of integration with digital learning technologies limits opportunities for flexible learning, continuous feedback, and the development of self-regulated learning skills.

Recent developments in educational technology have introduced Learning Management Systems (LMS) as effective tools to support digital and collaborative learning. One of the most

widely used LMS platforms is Moodle, which provides features such as digital learning modules, discussion forums, online quizzes with immediate feedback, and learning analytics. Previous studies have shown that integrating LMS into learning environments can significantly improve students engagement, collaboration, and self-regulated learning (Wahyuni & Pratiwi, 2021; Feng et al., 2025). However, existing studies also indicate that the integration of cooperative learning models, particularly STAD, with Moodle has not been systematically developed, especially in terms of designing learning syntax that is aligned with the characteristics of primary school students.

Based on the synthesis of previous research, a clear research gap can be identified. Although STAD has been proven effective in improving conceptual understanding, and LMS platforms such as Moodle have been shown to enhance self-regulated learning, there is still a lack of studies that integrate both approaches into a comprehensive and systematically developed learning model. In particular, the development of a Moodle-assisted STAD cooperative learning model that simultaneously targets conceptual understanding of fractions and self-regulated learning in primary schools remains limited.

Therefore, the purpose of this study is to develop a Moodle-assisted STAD cooperative learning model to improve primary school students conceptual understanding of fractions and self-regulated learning. This study is expected to contribute to the development of an innovative, technology-integrated cooperative learning model that supports meaningful, interactive, and student-centered mathematics learning in line with the demands of 21st-century education and the Merdeka Curriculum.

METHOD

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. This method was selected to develop a Moodle-assisted Student Teams Achievement Division (STAD) cooperative learning model and to examine its feasibility and effectiveness in improving primary school students conceptual understanding of fractions and self-regulated learning.

The participants of this study were fifth-grade primary school students in Bandung, West Java, Indonesia. A total of 56 students were selected through purposive sampling based on two criteria: (1) students academic ability levels and (2) the availability of adequate digital infrastructure to support the implementation of Moodle-based learning. In addition, several experts, including subject matter experts, media experts, and learning experts, were involved in the validation process of the developed learning model.

Several research instruments were used to collect data. These included:

1. a conceptual understanding test on fractions to measure students cognitive achievement
2. a self-regulated learning questionnaire to assess students learning independence and regulation strategies
3. a learning implementation observation sheet to evaluate the practicality of the developed model during classroom implementation;
4. student response questionnaires to obtain feedback on the learning experience; and
5. interview guidelines to collect qualitative data from teachers and students regarding the implementation of the model.

The research procedure followed the stages of the ADDIE model. In the analysis stage, a needs analysis was conducted through literature review, classroom observation, and identification of

problems related to students conceptual understanding of fractions and self-regulated learning. In the design stage, the syntax of the Moodle-assisted STAD model was designed, including the development of digital learning modules, interactive worksheets, and assessment instruments integrated into the Moodle platform. In the development stage, the initial prototype of the learning model and supporting learning materials were developed and validated by subject matter experts, media experts, and learning experts. Revisions were made based on expert feedback. In the implementation stage, the revised model was tested in a limited classroom setting involving fifth-grade students to evaluate its practicality and students responses. Finally, in the evaluation stage, the effectiveness of the developed model was examined by analyzing improvements in students conceptual understanding and self-regulated learning.

Data were analyzed using both quantitative and qualitative techniques. Quantitative data from the conceptual understanding tests and self-regulated learning questionnaires were analyzed using descriptive statistics and the normalized gain (N-gain) test to measure learning improvement between pre-test and post-test results. Meanwhile, qualitative data obtained from observations, interviews, and student responses were analyzed through data reduction, data presentation, and conclusion drawing to examine the feasibility, practicality, and implementation challenges of the developed learning model.

The research flow began with needs analysis → model design → product development and validation → limited implementation → effectiveness evaluation → final product revision, resulting in a valid, practical, and effective Moodle-assisted STAD learning model.

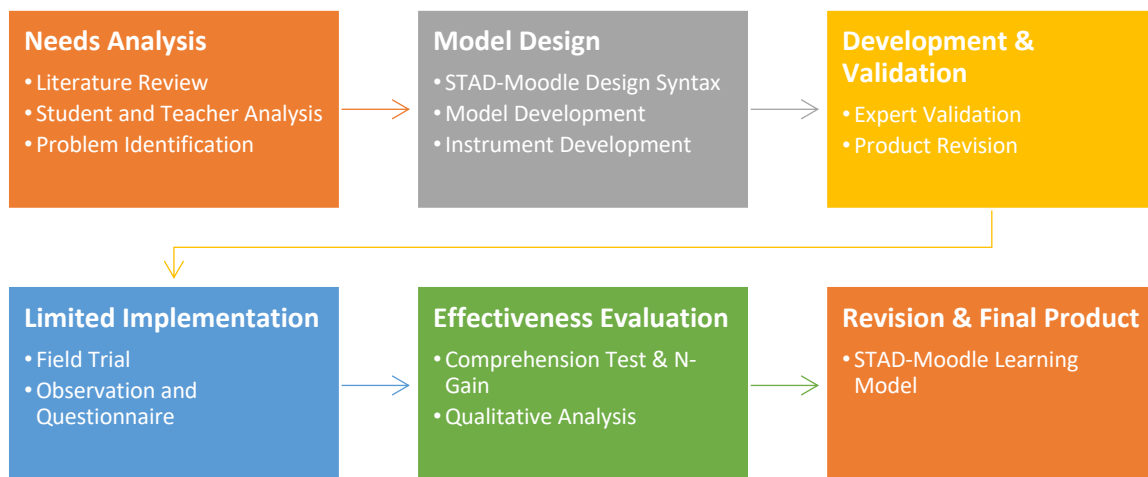


Figure 1. Model Design ADDIE

RESULTS AND DISCUSSION

Results

Development of the Moodle-Assisted STAD Cooperative Learning Model

This study aimed to develop a Moodle-assisted Student Teams Achievement Division (STAD) cooperative learning model to improve primary school students conceptual understanding of fractions and self-regulated learning. The development process followed the ADDIE model, including the stages of analysis, design, development, implementation, and evaluation.

The resulting product consisted of several components: the STAD–Moodle learning syntax, digital learning modules, interactive student worksheets, Moodle-based learning media, and assessment instruments to measure conceptual understanding and self-regulated learning. The

STAD–Moodle syntax was designed to overcome the limitations of conventional STAD by integrating structured digital learning activities, collaborative group discussions, formative assessments, and reflective learning through the Moodle platform.

The model implementation consisted of several learning stages: orientation and motivation, independent learning through Moodle materials, team discussion using STAD principles, digital quizzes and formative assessment, and reflection through Moodle feedback features. This structure was designed to encourage both collaborative learning and independent learning.

Model Validity and Feasibility

The developed model was validated by subject matter experts, media experts, and learning experts to ensure its feasibility for classroom implementation. The validation results showed that the STAD–Moodle model achieved a **very** high level of validity.

Table 1. Expert Validation Results

Validator	Percentage	Category
Subject Matter Experts	91.67%	Highly Feasible
Media Experts	87.50%	Highly Feasible
Learning Experts	91.67%	Highly Feasible
Average	91.07%	Very Good

Subject matter experts stated that the learning materials were aligned with the national curriculum learning outcomes (CP) and supported higher-order thinking skills through contextual fraction problems. Media experts highlighted that the Moodle interface, navigation system, and interactive features were well designed, although they recommended initial guidance for students unfamiliar with LMS platforms. Learning experts confirmed that the STAD learning syntax was clearly integrated into the Moodle environment, enabling structured collaborative learning.

Model Practicality

The practicality of the developed model was evaluated through teacher responses and classroom observations during implementation.

Teachers provided a practicality score of 92.50%, which falls into the **very** good category. The results indicated that teachers found the STAD–Moodle model easy to implement and helpful in increasing student participation during mathematics learning. Classroom observations also showed that students actively participated in group discussions, accessed digital materials independently, and demonstrated enthusiasm during Moodle-based activities.

Interview results further revealed that teachers perceived the model as effective for facilitating student monitoring, managing collaborative learning, and supporting formative assessment through the Moodle platform.

Effectiveness of the STAD–Moodle Model on Conceptual Understanding

The effectiveness of the model in improving students conceptual understanding of fractions was analyzed using pre-test and post-test **scores**, followed by Normalized Gain (N-gain) analysis.

Table 2. Summary of Students Conceptual Understanding Scores

Description	Pre-test	Post-test
Number of Students	56	56
Average Score	56.20	85.60
Highest Score	75	100
Lowest Score	40	70

The results show a substantial improvement in students conceptual understanding after the implementation of the STAD–Moodle model. The average score increased from 56.20 in the pre-test to 85.60 in the post-test.

Further analysis using the N-gain test produced an average value of 0.67, which falls into the moderate–high **effectiveness category**. This result indicates that the integration of STAD cooperative learning with Moodle-based digital activities significantly improved students understanding of fraction concepts.

This improvement can be attributed to several factors. First, the availability of interactive digital learning materials allowed students to revisit mathematical concepts independently. Second, collaborative discussions in STAD **teams** helped students clarify misconceptions and develop conceptual explanations through peer interaction. Third, the use of Moodle-based quizzes with immediate feedback enabled students to monitor their own learning progress.

Improvement of Students Self-Regulated Learning

In addition to conceptual understanding, this study also examined the effect of the STAD–Moodle model on **students** self-regulated learning. Data were collected using a self-regulated learning questionnaire administered before and after the implementation of the model.

Table 3. N-Gain Results for Self-Regulated Learning

Parameter	Value
Average Initial Score	58.40
Average Final Score	86.10
Maximum Score	100
N-gain	0.66
Category	Moderate–High

The results indicate a significant increase in students self-regulated learning, with **an** N-gain value of 0.66, which is categorized as moderate–high improvement.

The improvement in self-regulated learning occurred because students were encouraged to engage in self regulated learning activities through Moodle, such as accessing digital materials, completing assignments, reviewing feedback, and reflecting on their learning progress. These activities allowed students to develop learning autonomy and responsibility, which are key components of self-regulated learning.

Student and Teacher Responses to Moodle-Based Learning

The Moodle platform created a digital learning environment that supported both independent learning and collaborative interaction. Several features contributed to the effectiveness of the learning process:

1. Interactive digital worksheets, allowing students to complete tasks directly within the LMS

2. Immediate feedback through online quizzes, helping students identify errors and improve understanding
3. Structured discussion spaces, enabling cooperative learning within STAD teams
4. Flexible **access to** learning materials, allowing students to review concepts according to their own learning pace

Interview results indicated that both teachers and students responded positively to the implementation of the STAD–Moodle model. Students reported that mathematics learning became more interesting, interactive, and motivating, while teachers highlighted the benefits of better monitoring of student progress and improved quality of group discussions.

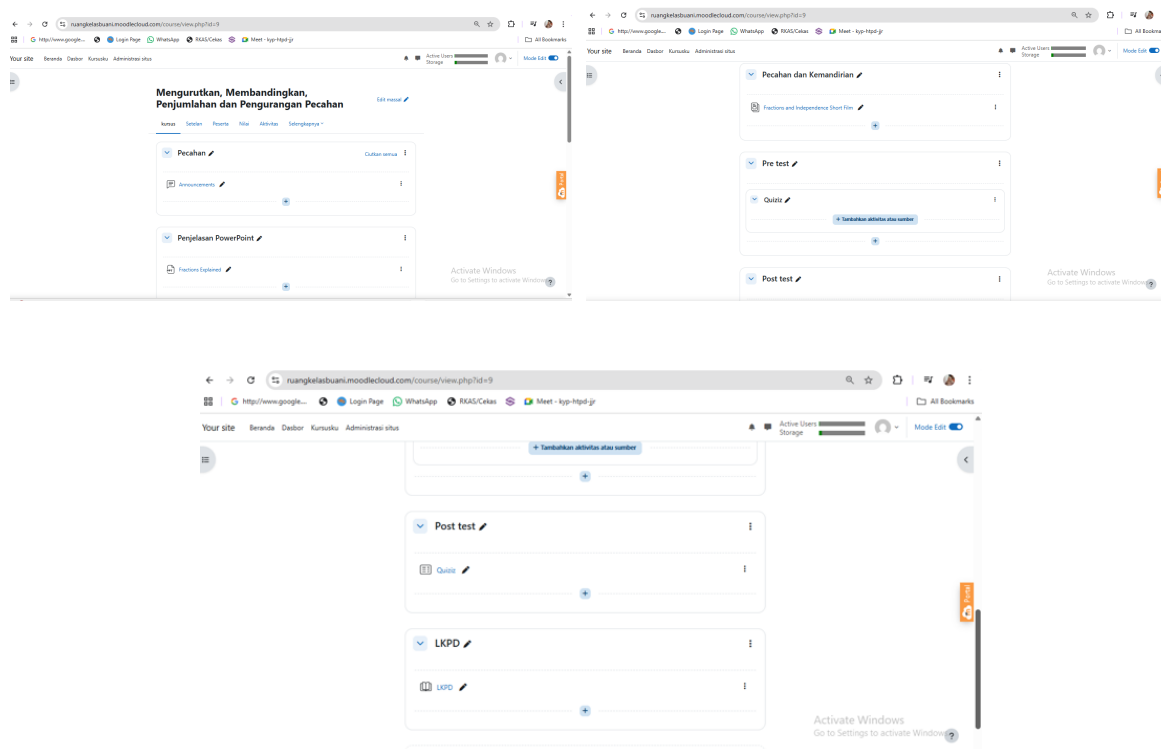


Figure 2. The Moodle LMS

Summary of Findings

Overall, the results of this study indicate that:

1. The STAD–Moodle cooperative learning model is valid and feasible, with an average expert validation score of 91.07%.
2. The model is practical for classroom implementation, as indicated by a teacher practicality score of 92.50%.
3. The model is effective in improving students conceptual understanding of fractions, with an N-gain value of 0.67 (moderate–high category).
4. The model is also effective in enhancing students self-regulated learning, with an N-gain value of 0.66 (moderate–high category).

These findings demonstrate that the integration of STAD cooperative learning and Moodle-based digital learning can create a more interactive, collaborative, and student-centered mathematics learning environment in primary schools.

Discussions

The results of this study indicate that the Moodle-assisted Student Teams Achievement Division (STAD) cooperative learning model effectively improves primary school students conceptual understanding of fractions and self-regulated learning. The effectiveness of the model is reflected in the N-gain value of 0.67 for conceptual understanding **and** 0.66 for self-regulated learning, both categorized as moderate–high improvement. These findings suggest that integrating cooperative learning with digital learning platforms can create a more interactive and student-centered learning environment.

The improvement in conceptual understanding occurred because students were actively involved in collaborative discussions, independent exploration of learning materials, and reflective learning activities. The Moodle platform provided structured digital learning resources, interactive quizzes, and immediate feedback, which helped students strengthen their conceptual comprehension of fractions. At the same time, the learning structure encouraged students to take responsibility for their own learning process, thereby improving their self-regulated learning skills.

The findings of this study are consistent with several previous studies that highlight the effectiveness of cooperative learning and digital learning integration in mathematics education. First, the improvement in students conceptual understanding supports the findings of Sari et al. (2020), who reported that the STAD cooperative learning model significantly enhances students conceptual understanding in mathematics. Both studies emphasize that group discussion and peer explanation enable students to construct knowledge collaboratively and correct misconceptions through social interaction.

Second, the results of this study align with the research conducted by Wahyuni and Anugraheni (2021), which found that technology-supported learning environments improve students mathematical learning outcomes and engagement. While their research focused on the use of digital learning media, the present study extends these findings by integrating Learning Management System (LMS) technology within the STAD cooperative learning structure.

Third, the increase in students self-regulated learning observed in this study is consistent with the findings of Handayani and Huda (2020), who demonstrated that digital learning platforms can encourage students to take greater responsibility for their learning activities. In the current study, Moodle features such as digital assignments, learning progress tracking, and instant feedback supported students in managing their learning activities more independently.

Fourth, the results also support the theoretical framework of self-regulated learning proposed by Zimmerman (2002), which emphasizes the importance of planning, monitoring, and evaluating learning processes. The Moodle platform enabled students to repeatedly access learning materials, complete quizzes independently, and evaluate their performance through automated feedback, thereby strengthening their metacognitive awareness.

Fifth, the effectiveness of integrating cooperative learning and digital learning environments found in this study confirms the results of Dewi and Hilman (2018) **and** Rusman (2017), who concluded that combining collaborative learning strategies with e-learning platforms enhances student engagement, motivation, and learning outcomes.

In addition to comparisons with previous studies, this research also highlights the pedagogical differences between conventional STAD and the Moodle-assisted STAD model developed in this study. In conventional STAD implementation, learning activities are generally conducted through face-to-face discussions, teacher explanations, and paper-based quizzes. Although this approach supports collaborative learning, it often lacks structured digital learning resources, systematic reflection, and flexible learning opportunities outside the classroom.

In contrast, the STAD–Moodle model integrates digital technology into each stage of the learning process, enabling students to access materials independently, participate in structured online discussions, and receive immediate feedback on their learning outcomes. This integration allows the learning process to become more interactive, flexible, and supportive of students independent learning.

Table 4. Comparison between Conventional STAD and STAD–Moodle

Learning Stage	Conventional STAD	STAD–Moodle
Introduction	Teacher-centered explanation	Digital motivation through videos and quizzes
Concept exploration	Lecture and board explanation	Interactive digital modules and multimedia
Group discussion	Face-to-face discussion	Collaborative discussion supported by Moodle forums
Assessment	Paper-based quizzes	Online quizzes with automatic feedback
Reflection	Rarely implemented	Digital reflection and learning feedback
Learning monitoring	Teacher observation	LMS-based learning analytics

This comparison demonstrates that the integration of Moodle transforms the traditional STAD model into a more systematic, technology-supported cooperative learning model.

From a theoretical perspective, this study contributes to the development of cooperative learning theory by demonstrating how traditional cooperative learning models can be enhanced through digital learning technologies. The integration of Moodle expands the scope of STAD learning activities beyond classroom interaction by incorporating digital collaboration, independent learning, and reflective learning processes.

Furthermore, this study reinforces the theoretical relationship between cooperative learning and self-regulated learning. Cooperative learning encourages social interaction and knowledge construction, while digital learning platforms facilitate independent learning and metacognitive reflection. The integration of these two approaches creates a learning environment that supports both social learning and individual learning regulation.

From a practical perspective, the findings of this study provide important implications for teachers and educational practitioners. The STAD–Moodle learning model offers an innovative approach for designing interactive and technology-integrated mathematics learning in primary schools. Teachers can use Moodle to provide digital learning materials, manage collaborative discussions, conduct online assessments, and monitor student learning progress more effectively. In addition, the model encourages students to actively participate in collaborative learning while simultaneously developing independent learning habits.

The STAD–Moodle model is also relevant to the implementation of technology-based learning approaches in the Merdeka Curriculum, which emphasizes student-centered learning, collaboration, and digital literacy. Despite the positive findings, this study has several limitations. First, the research was conducted on a limited sample of primary school students, which may affect the generalizability of the results. Second, the implementation period was relatively short, so the long-term impact of the STAD–Moodle model on students conceptual understanding and self-regulated learning could not be fully examined.

Future research is recommended to involve larger and more diverse samples, as well as to investigate the long-term effectiveness of the STAD–Moodle model in different learning

contexts and mathematical topics. In addition, further studies may explore the integration of other digital learning technologies to enhance cooperative learning models in primary education.

CONCLUSION

This study aimed to develop and evaluate a Moodle-assisted Student Teams Achievement Division (STAD) cooperative learning model to improve primary school students conceptual understanding of fractions and self-regulated learning. The results of the study indicate that the developed STAD–Moodle model is valid, practical, and effective for use in primary school mathematics learning. Expert validation results showed that the model achieved a high level of feasibility in terms of learning syntax, content suitability, media design, and integration with the Moodle platform.

The implementation results demonstrated that the STAD–Moodle model significantly improved students conceptual understanding of fractions, as indicated by an N-gain value of 0.67, which falls into the moderate–high category. In addition, students self-regulated learning also increased, with an N-gain value of 0.66, indicating that the model effectively encourages students to manage their learning activities independently through digital learning resources, structured collaboration, and reflective learning processes.

These findings suggest that integrating cooperative learning strategies with Learning Management System (LMS) technology can create a more interactive, collaborative, and student-centered learning environment in primary mathematics education. Therefore, the STAD–Moodle model can be considered an innovative instructional alternative for improving both students conceptual understanding and learning independence.

However, this study was conducted within a limited research context involving a relatively small number of participants and a specific mathematical topic. Future research is recommended to involve larger and more diverse samples, examine the long-term impact of the model on students learning outcomes, and explore the application of the STAD–Moodle model in other mathematical topics or different educational levels.

ACKNOWLEDGMENTS

Special thanks are also extended to the authors' families for their continuous encouragement and motivation. In addition, the authors would like to thank all students who participated in this study for their cooperation and support throughout the research process. Thanks are also extended to colleagues from the Basic Education Program at IKIP Siliwangi for their meaningful discussions, collaboration, and encouragement.

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