

Developing and Validating Contextual Learning Instructional Materials for Two-Variable Linear Equation Systems in Senior High School Mathematics

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ABSTRACT

Background: The quality of mathematics instruction is strongly influenced by the availability of well-designed instructional materials that actively engage students and connect abstract concepts to real-life contexts. In practice, mathematics learning at the secondary level often remains teacher-centered, limiting students' opportunities to construct meaning independently. This condition is particularly evident in learning systems of linear equations in two variables, where procedural instruction dominates and contextual understanding is minimal. Therefore, developing instructional materials grounded in contextual learning principles is essential to improve instructional quality and learning effectiveness.

Aims: This study aimed to develop and validate contextual learning-based instructional materials for the topic of two-variable linear equation systems at the senior high school level and to examine their effectiveness in supporting classroom learning.

Methods: This research employed a development research design using a modified 4-D model, limited to the define, design, and develop stages. The instructional materials produced consisted of lesson plans, student worksheets, and achievement tests. Validation by subject-matter experts, classroom trials, and implementation phases were conducted to evaluate validity, practicality, and effectiveness. Data were collected through validation sheets, classroom observation instruments, student response questionnaires, and learning achievement tests.

Results: The findings indicated that all instructional materials met the criteria of validity with expert evaluations categorized as good. Teachers' instructional management was consistently rated effective, student learning activities aligned with planned instructional phases, and student responses toward the learning process were predominantly positive. Classical learning mastery was achieved, demonstrating the effectiveness of the developed materials.

Conclusion: The study confirms that contextual learning-based instructional materials can significantly enhance the quality of mathematics instruction by fostering active student engagement, meaningful learning experiences, and improved learning outcomes. The integration of real-life contexts into mathematical instruction supports students' conceptual understanding and problem-solving abilities. These findings contribute to instructional development research by providing empirically validated materials that align with contemporary pedagogical demands. The results also offer practical implications for mathematics educators seeking to implement contextual learning approaches and support curriculum innovation in secondary education settings.

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INTRODUCTION

Mathematics education at the secondary level continues to encounter persistent challenges related to students' conceptual understanding and meaningful engagement in learning processes. Instructional practices in algebra frequently emphasize symbolic manipulation and procedural fluency rather than conceptual reasoning and contextual interpretation. This tendency is particularly evident in the teaching of systems of linear equations in two variables, where students often struggle to connect mathematical representations with real-life situations. As a consequence, learning outcomes commonly reflect short-term procedural success rather than long-term conceptual understanding. Such conditions limit students' ability to apply mathematical knowledge flexibly across contexts. Contextual learning has been widely recognized as an instructional approach that situates mathematical concepts within authentic and meaningful situations. Empirical evidence indicates that contextualized instruction enhances students' motivation, reasoning skills, and conceptual comprehension (De La Paz et al., 2022; Ferede et al., 2025). Therefore, strengthening mathematics instruction through contextual learning remains a critical educational priority.

The urgency of this research is further driven by the increasing demand for instructional innovation aligned with contemporary curriculum frameworks. Systems of linear equations in two variables represent a foundational topic in algebra and serve as a prerequisite for advanced mathematical learning. Despite its importance, many existing instructional resources fail to integrate contextual learning principles in a systematic and coherent manner. Students are often presented with abstract tasks detached from meaningful contexts, which restricts their ability to transfer mathematical knowledge beyond classroom settings. Prior studies in mathematics education demonstrate that carefully designed contextual tasks can support deeper conceptual understanding and problem-solving skills (Ferede et al., 2025; Ncube & Luneta, 2025; Reinke & Casto, 2022). However, the availability of empirically validated instructional materials that operationalize contextual learning remains limited. Teachers frequently rely on fragmented or self-developed resources without rigorous evaluation. This situation underscores the need for research focused on developing high-quality instructional materials grounded in contextual learning theory.

In addition to pedagogical challenges, the gap between educational theory and classroom practice further amplifies the need for this study. Although contextual learning has been extensively discussed in educational literature, its classroom implementation often lacks consistency and instructional support. Teachers require structured instructional materials that translate pedagogical principles into coherent learning experiences aligned with curriculum standards. Development research offers a systematic approach for designing, validating, and refining instructional materials based on empirical evidence. By emphasizing instructional material development, research can move beyond measuring outcomes toward improving instructional processes. Validation and classroom trials ensure that instructional materials are not only theoretically sound but also practical and effective. Such an approach supports teacher professionalism by providing reliable and ready-to-use instructional resources. Consequently, developing and validating contextual learning-based instructional materials constitutes a timely and significant contribution to mathematics education research.

The rationale for this study is grounded in the need to bridge theoretical perspectives on contextual learning with consistent and effective classroom implementation in mathematics education. Although contextual learning has been widely promoted as an approach that enhances meaningful learning, its application in secondary mathematics classrooms often remains fragmented. Teachers frequently encounter difficulties in translating pedagogical theories into structured instructional practices that align with curriculum standards. As a result, contextual learning is sometimes applied superficially without clear instructional coherence. Development research provides a systematic framework for designing, validating, and refining instructional materials to address this challenge (Fang et al., 2024; Tinoca et al., 2022). By emphasizing instructional material development, research can focus on improving the quality of learning processes rather than solely measuring learning outcomes. This approach ensures alignment among learning objectives, instructional activities, and assessment strategies. Consequently, development-oriented studies play a critical role in supporting effective and sustainable instructional innovation.

Another important rationale lies in the need to provide empirically validated instructional resources that support teacher professionalism. Many teachers rely on self-developed materials that lack rigorous validation, which may limit instructional effectiveness. Research has shown that instructional materials developed through systematic design processes are more likely to support student engagement and learning achievement (Johar et al., 2023; Xu et al., 2023). Validation and classroom trials help ensure that instructional materials are not only theoretically sound but also practical for real classroom contexts. Moreover, well-designed instructional materials can reduce teachers' dependence on procedural teaching methods and encourage student-centered learning. This is particularly relevant for algebra instruction, where abstract concepts often hinder student understanding. By developing contextual learning-based instructional materials, this study responds to the need for scalable and evidence-based

instructional solutions. Thus, the research offers meaningful contributions to both instructional design research and classroom practice in mathematics education.

Recent Scopus-indexed studies highlight the growing emphasis on contextual and culture-based learning in mathematics education. Panjaitan et al., (2025) demonstrated that integrating cultural contexts into mathematics instruction enhances student engagement and conceptual understanding. Isharyadi & Nurjanah, (2025) emphasized the importance of instructional design in promoting deeper reasoning through contextualized geometry learning. Prahmana et al., (2025) showed that embedding moral and cultural contexts in mathematics learning supports meaningful knowledge construction. Sukasno et al., (2024) reported that contextual learning trajectories improve students' conceptual understanding in fraction learning. Mujib et al., (2021) found that contextual learning supported by digital media enhances instructional effectiveness and student motivation. Yousuf et al., (2010) highlighted the value of project-based and contextual approaches in fostering active learning. Additionally, Badioze Zaman et al., (2009) demonstrated that visualization-supported contextual learning improves comprehension in science and mathematics education. Collectively, these studies underline the importance of systematically developed instructional materials that operationalize contextual learning principles.

Despite the growing body of research on contextual learning, several gaps remain evident in the literature. Many studies focus on learning outcomes without providing detailed descriptions of the instructional materials used. There is limited research that integrates validity, practicality, and effectiveness within a single instructional development framework. Moreover, few studies specifically address the development of contextual learning-based materials for systems of linear equations in two variables. Existing instructional resources often lack empirical validation through classroom implementation. This limits teachers' confidence in adopting contextual learning approaches consistently. Furthermore, prior studies rarely report comprehensive evaluation processes involving expert validation and classroom trials. These limitations indicate the need for development research that produces empirically tested instructional materials. Therefore, this study seeks to address these gaps by developing and validating contextual learning-based instructional materials grounded in classroom practice.

The purpose of this study is to develop and validate contextual learning-based instructional materials for teaching systems of linear equations in two variables at the senior high school level. The study aims to evaluate the validity of lesson plans, student worksheets, and achievement tests through expert review. It also seeks to examine the practicality of the materials based on classroom implementation and teacher instructional performance. Additionally, the effectiveness of the instructional materials is assessed through student learning activities and achievement outcomes. By employing a development research approach, this study provides empirical evidence on instructional quality. The findings are expected to contribute to instructional design research in mathematics education. The study also aims to support teachers in implementing contextual learning more effectively. Ultimately, this research seeks to enhance the quality of mathematics instruction through evidence-based instructional material development.

METHOD

Research Design

This study employed a development research design aimed at producing and validating contextual learning-based instructional materials for senior high school mathematics. The development process followed the 4-D model proposed by Thiagarajan, Semmel, and Semmel, which was modified by excluding the dissemination stage to suit the research objectives (Pernantah et al., 2023). The stages implemented included define, design, and develop, ensuring systematic instructional material construction. The design focused on aligning learning objectives, instructional activities, and assessment components within a contextual learning framework. Development research was selected to emphasize

instructional quality rather than solely measuring learning outcomes. This approach is consistent with recommendations for instructional design studies that prioritize validity, practicality, and effectiveness (Divjak et al., 2023; Ruiz-Rojas et al., 2023).

Participants

The participants of this study consisted of senior high school students enrolled in Grade X mathematics classes. One class was involved in the trial phase to evaluate the practicality and initial effectiveness of the developed instructional materials. A second class participated in the implementation phase to examine instructional effectiveness under authentic classroom conditions. A mathematics teacher served as the instructional facilitator during both phases. Additionally, expert validators with expertise in mathematics education were involved in the validation process. The selection of participants was intended to reflect typical classroom settings in secondary mathematics education.

Instruments

Several research instruments were used to collect data on the quality of the instructional materials. Expert validation sheets were employed to assess the content validity, instructional coherence, and linguistic clarity of the lesson plans, student worksheets, and achievement tests. Observation sheets were used to evaluate teachers’ instructional management during classroom implementation. Student activity observation sheets were applied to examine alignment between planned instructional phases and actual learning activities. Student response questionnaires were administered to capture learners’ perceptions of the instructional materials and learning process. Achievement tests were used to measure students’ learning outcomes following instructional implementation.

Data Analysis Plan

Data analysis was conducted using descriptive quantitative and qualitative techniques. Validation data were analyzed by calculating mean scores to determine the validity level of each instructional component. Teacher instructional management and student activity data were analyzed descriptively to assess practicality and instructional effectiveness. Student response data were analyzed using percentage calculations to determine the proportion of positive responses. Learning achievement data were analyzed to determine classical mastery based on predetermined criteria. The instructional materials were considered effective when validity, practicality, and effectiveness indicators were simultaneously fulfilled, following established instructional development evaluation principles (Dahal et al., 2023; Liao et al., 2023).

RESULTS AND DISCUSSION

Results

The results indicate that the developed contextual learning-based instructional materials met the established quality criteria. Expert validation showed that the lesson plans, student worksheets, and achievement tests achieved good validity across content, instructional structure, and language clarity. Validators confirmed that the instructional components were aligned with curriculum objectives and contextual learning principles. Classroom observations demonstrated that teachers were able to implement the instructional materials effectively across all learning sessions. Student learning activities followed the planned instructional phases within the acceptable time tolerance. Student responses toward the instructional materials and learning process were predominantly positive. Learning achievement analysis revealed that classical mastery exceeded the minimum threshold. These findings indicate that the developed instructional materials functioned effectively in real classroom contexts.

Table 1. Summary of Instructional Material Quality Evaluation

Evaluation Aspect	Indicator	Result
Validity	Expert judgment on RPP, worksheets, tests	Valid (Good category)
Practicality	Teacher instructional management	Effective
Student Activity	Alignment with instructional phases	Effective

Evaluation Aspect	Indicator	Result
Student Response	Positive perception	≥ 80% positive
Learning Achievement	Classical mastery	≥ 70%

Classroom implementation results further demonstrated the effectiveness of the instructional materials. Teachers’ instructional management consistently met the minimum good category in all observed sessions. Student activities reflected active engagement in contextual problem-solving tasks. The integration of real-life contexts supported students’ conceptual understanding of linear equation systems. Achievement test results showed improved student performance compared to initial assessments. The reliability and sensitivity of the achievement test met acceptable criteria. These results confirm the consistency between instructional design and learning outcomes. Overall, the materials supported meaningful mathematics learning.

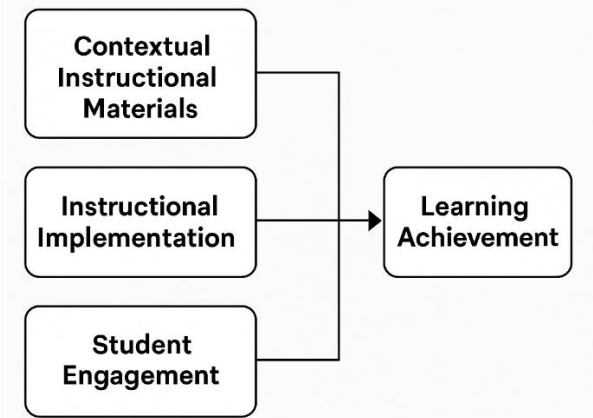


Figure 1. Conceptual Relationship Between Contextual Instructional Materials and Learning Effectiveness

Figure 1 illustrates the relationship between contextual learning-based instructional materials, instructional implementation quality, student engagement, and learning achievement. The figure conceptualizes how validated instructional design mediates effective learning processes.

Discussion

The findings of this study reinforce the importance of instructional material quality in contextual mathematics learning. The validated instructional materials enabled teachers to implement contextual learning consistently, which aligns with previous research emphasizing instructional coherence (Reiser et al., 2021; Salloum, 2022). Contextual learning supported students’ active engagement by connecting abstract algebraic concepts to meaningful situations (Johnson, 2014). Similar results were reported by Hosnan (2014), who found increased student motivation through contextual approaches. The structured instructional design also reduced teacher dependency on procedural explanations. This supports (Sørensen et al., 2023; Soubra et al., 2022) assertion that student-centered instructional strategies improve learning outcomes. The alignment between instructional phases and student activities further indicates effective instructional orchestration. These results highlight the instructional value of development-based research.

The positive student responses suggest that contextual learning enhanced students’ perceptions of mathematics relevance. Meaningful learning experiences were fostered through problem situations drawn from everyday contexts, as also observed by Prahmana et al. (2025). Contextualization allowed students to interpret solutions rather than merely compute answers. This finding aligns with Sukasno et al. (2024), who reported improved conceptual understanding through contextual learning trajectories. The instructional materials facilitated collaborative learning and discussion. Such interaction supports deeper reasoning processes as noted by (Ramos et al., 2022). Students’ sustained engagement throughout learning sessions indicates effective task design. These outcomes confirm the pedagogical benefits of contextual learning.

From an instructional design perspective, the integration of expert validation and classroom trials strengthened material quality. Development research emphasizes iterative refinement as a key to instructional effectiveness (Carless, 2023; Spyropoulou & Kameas, 2023). The validation process ensured alignment between learning objectives, instructional activities, and assessment components. This finding is consistent with (Van De Berg et al., 2024), who emphasized formative evaluation in instructional design. Classroom trials provided empirical evidence of practicality. Teachers' ability to manage learning effectively suggests instructional feasibility. The findings also support Mujib et al. (2021), who highlighted the role of well-designed materials in contextual learning. Therefore, instructional development should be prioritized alongside pedagogical innovation.

The effectiveness of contextual learning-based materials also contributes to broader mathematics education goals. Developing conceptual understanding in algebra is critical for students' future mathematical learning. Contextual learning promotes transferability of knowledge to real-world situations (Johnson, 2014). The findings align with international calls for meaningful mathematics education that transcends procedural competence (Geiger et al., 2023). Furthermore, the results support the integration of contextual learning into curriculum implementation. This study extends prior research by focusing on instructional material validation rather than solely learning outcomes. The evidence provided strengthens the case for development-oriented research in education. Thus, this study contributes both empirically and pedagogically to mathematics education literature.

Implications

The findings of this study have important implications for mathematics instruction at the secondary level. Teachers can utilize validated contextual learning-based instructional materials to enhance student engagement and conceptual understanding. Curriculum developers may adopt similar development frameworks to ensure instructional quality. The study highlights the importance of aligning instructional design with learning objectives and assessment. Educational institutions can support teachers by providing access to empirically validated instructional resources. Professional development programs should include training on contextual learning implementation. Overall, the study supports evidence-based instructional innovation in mathematics education.

Limitations

Despite its contributions, this study has several limitations. The research was conducted in a limited number of classroom settings, which may affect generalizability. The instructional materials focused on a single algebraic topic. Long-term learning retention was not examined. Student learning outcomes were measured using achievement tests only. Qualitative insights from student interviews were not included. Future studies should address these limitations to strengthen findings.

Suggestions

Future research should expand contextual learning-based instructional development to other mathematical topics. Longitudinal studies are recommended to examine learning retention and transferability. Researchers may incorporate qualitative methods to explore student reasoning processes. Comparative studies with other instructional approaches could provide deeper insights. Digital integration of contextual learning materials may enhance accessibility. Continued instructional development research is essential to improve mathematics education quality.

CONCLUSION

The findings of this study demonstrate that contextual learning-based instructional materials can be systematically developed and validated to support effective mathematics instruction at the senior high school level. The lesson plans, student worksheets, and achievement tests met the criteria of validity through expert evaluation and were shown to be practical during classroom implementation. Teachers were able to manage learning activities effectively by following the structured instructional design embedded in the materials. Students actively participated in learning processes that emphasized real-life

contexts and conceptual understanding. Positive student responses indicated that contextual learning increased the perceived relevance and meaningfulness of mathematics instruction. Learning achievement results further confirmed that classical mastery was successfully achieved. These outcomes indicate that well-designed instructional materials play a central role in facilitating high-quality teaching and learning processes. Therefore, instructional material development should be regarded as a strategic component of mathematics education improvement.

Beyond immediate instructional outcomes, this study provides broader contributions to mathematics education research and practice. The development research approach employed in this study offers a practical model for aligning pedagogical theory with classroom realities. By emphasizing validity, practicality, and effectiveness, the study strengthens the methodological rigor of instructional design research. The contextual learning framework applied in this research supports the development of students' conceptual reasoning and problem-solving skills. The findings suggest that contextual instructional materials can enhance instructional sustainability by reducing teacher dependency on procedural teaching methods. This study also underscores the importance of evidence-based instructional resources for supporting curriculum implementation. Consequently, the research contributes to advancing meaningful mathematics learning aligned with contemporary educational demands. Overall, the study offers a strong foundation for future instructional innovation and research in mathematics education.

AUTHOR CONTRIBUTIONS STATEMENT

Maria Carmelita Tali Wangge conceived the research idea and designed the overall study framework. She developed the contextual learning-based instructional materials used in the research. The author conducted data collection during the validation, trial, and classroom implementation phases. Data analysis and interpretation of findings were performed independently by the author. She was responsible for drafting the initial manuscript and revising it critically to strengthen its academic quality. The author ensured alignment between the research objectives, methodology, and results. Final approval of the manuscript for publication was given by the author. The author assumes full responsibility for the integrity and accuracy of the research work.

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