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Development of Bilingual Mathematics Questions Based on Sidoarjo Local Wisdom for Two-Variable Linear Equation Systems

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ABSTRACT

This development research aims to produce bilingual mathematics questions on the topic of a Two-Variable Linear Equation System based on the local wisdom of Sidoarjo, Indonesia. The study employed the 4-D development model, encompassing the stages of Define, Design, Develop, and Disseminate. The study was conducted at Ten November Junior High School of Sidoarjo, a school with a bilingual program. The subjects for the product trial were 25 ninth-grade students. The primary outcome is a set of five bilingual test questions. The results demonstrate that the developed questions are highly valid based on expert judgment using the Content Validity Index (CVI) and empirical validity tests using Pearson Product-Moment correlation, where the r-count for all items exceeded the r-table (0.396) with a significance value of $p < 0.05$. The reliability test, measured by Cronbach's Alpha, yielded a score of 0.855, indicating high internal consistency. Furthermore, the questions proved effective, as evidenced by the majority of students achieving the minimum mastery criteria and their positive questionnaire responses regarding the questions' readability, benefits, and appeal. In conclusion, the bilingual mathematics questions based on Sidoarjo's local wisdom are valid, reliable, and effective, making them a suitable instrument for evaluation and a potential alternative learning resource.

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INTRODUCTION

In the current era of globalization, the development of literacy and numeracy skills is essential for students to face increasingly complex global challenges (Ramamonjisoa, 2024). Numeracy, which includes the ability to understand, interpret, and apply numbers and data in everyday situations, is systematically cultivated through mathematics education (Susanto et al., 2021). This discipline plays a critical role in shaping critical, analytical, and problem-solving thinking skills needed in various aspects of life (Sulistiani & Masrukan, 2016). However, a significant obstacle in mathematics learning is low student engagement, often because the material is perceived as abstract and difficult to understand (Jayanti et al., 2022).

The use of culturally relevant, local context-based materials can enhance students' understanding of mathematical concepts (Sayangan, 2024). Students involved in learning

based on local contexts demonstrate better outcomes compared to those taught using conventional approaches (Ipat & Nindiasari, 2024). In Sidoarjo, Indonesia, only three cultural systems are most prominent in Sidoarjo: arts, religious systems, and livelihood systems (Safina & Budiarto, 2022). In Sidoarjo, various aspects of local culture and economy such as the Banjar Kemuning Dance (Wowiling, 2024), Reog Cemandi (Supriyadi, 2024), Woven Craft (Ikromah, 2025), and Petis (Insani, 2016) (a traditional condiment) can serve as contexts for developing math problems. By linking mathematical concepts to students' daily lives, learning becomes more meaningful and engaging, aligning with constructivist theory which posits that knowledge is actively built by students through experiences and interactions with their environment (Vygotsky et al., 2012).

The strategic decision to develop materials for the Two-Variable Linear Equation System (SPLDV), as opposed to other mathematical topics, is grounded in its unique pedagogical role as a fundamental gateway to mathematical modeling. SPLDV represents students' first formal encounter with a system of equations, requiring them to identify and relate two interdependent variables—a critical competency in algebraic reasoning and a precursor to more advanced topics (Ramírez-Montes et al., 2021). However, students often struggle with this topic because textbook problems are frequently abstract and disconnected from their daily experiences (Hakika et al., 2024). To bridge this gap, a contextual approach that links lessons to students' cultural environment is essential. Furthermore, within the Indonesian educational context, there is a pressing need for assessment tools that not only measure cognitive competencies but also respect linguistic and cultural diversity (Mendoza, 2024). The bilingual (Indonesian-English) question approach aims to enhance mathematical and language literacy simultaneously, while also familiarizing students with English mathematical terminology prevalent in academic and professional literature (Baker & Wright, 2021).

Although previous studies have developed questions based on local wisdom, a specific gap exists concerning Two-Variable Linear Equation System material. Prior research (Nisa, 2021) focused on geometry, while others (Ranti, 2022; Kholifah, 2024) developed bilingual devices or AKM-based questions but did not explicitly integrate both bilingual aspects and Sidoarjo's local wisdom into Two-Variable Linear Equation System material. Therefore, this research is vital to fill this gap.

This study aims to develop bilingual mathematics questions on the topic of the Two-Variable Linear Equation System based on the local wisdom of Sidoarjo. The specific purposes of this study are:

1. To describe the development process of these questions using the 4-D model (Define, Design, Develop, Disseminate).

2. To determine the validity, reliability, and effectiveness of the developed bilingual mathematics questions based on Sidoarjo's local wisdom on the topic of the Two-Variable Linear Equation System.

It is expected that the resulting product will be a valid, reliable, and effective assessment instrument, suitable for use as an evaluation tool and an alternative learning medium that enriches students' learning experiences, improves academic achievement, and fosters a greater appreciation for local cultural values.

METHOD

Research Design. This study employs the Research and Development (R&D) method, adopting the 4D model. In 1974, S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel developed the 4-D model, which includes the stages of Define, Design, Development, and Dissemination (Slamet, 2022). This model was selected for its systematic and structured framework, which is highly suitable for developing educational instruments like test items (Mesra et al., 2023).

Participants and Research Location. The study was conducted at Ten November Junior High School of Sidoarjo, a school with a bilingual program. The subjects for the product trial were 25 ninth-grade students. Additionally, three validators consisting of two mathematics education lecturers from PGRI Delta University and one mathematics teacher from the school were involved in the product validation phase.

Instruments. The primary product of this research was a set of five bilingual (Indonesian-English) mathematics essay questions on the topic of the Two-Variable Linear Equation System, contextualized within the local wisdom of Sidoarjo (e.g., Reog Cemandi, Banjar Kemuning Dance, Woven Craft, Petis). The research instruments included:

1. Expert Validation Sheets: Used to assess the content validity of the questions based on material, construct, and language aspects. The sheets utilized a Guttman scale (Yes/No) and open-ended sections for comments and suggestions.
2. Test Questions: The five developed essay questions were used to collect data on empirical validity, reliability, and student learning outcomes.
3. Student Response Questionnaire: An 18-item questionnaire using a 4-point Likert scale (Strongly Agree to Strongly Disagree) was used to measure the effectiveness of the questions from the students' perspectives, covering aspects of local wisdom and bilingual presentation.

Procedure. The research procedure followed the 4-D model stages (Define, Design, Develop, Disseminate)(Lawhon, 1976). The Define stage established the foundation for development through a comprehensive analysis. This involved: (1) a

Front-End Analysis, where interviews with mathematics teachers and a literature review identified key issues, including the abstract nature of the Two-Variable Linear Equation System and a lack of learning materials integrating local context; (2) a Learner Analysis to examine the characteristics of ninth-grade students, particularly their academic abilities and familiarity with bilingual instruction; (3) a Concept Analysis to break down the core learning outcomes for Two-Variable Linear Equation System based on the national curriculum; and (4) a Task Analysis to formulate detailed learning objectives and competency indicators. The outcomes of these analyses were then synthesized into specific instructional objectives to guide the product development.

In the Design stage, the initial product prototype was created. A test grid was constructed based on the competency indicators established in the previous stage. This was followed by the drafting of five bilingual essay questions that incorporated the local wisdom of Sidoarjo. A corresponding scoring rubric was also developed for each question to ensure objective assessment. This initial design of the questions and assessment instruments was then prepared for validation.

The Develop stage focused on refining the prototype into a viable final product. This began with an Expert Appraisal, where the initial product was validated by three experts in the field. Their feedback pertained to the content, construct, and language of the questions, and was used to revise and improve the product. Following this validation, the revised product was tested in a limited trial with students. Data from this test were used to analyze empirical validity, reliability, and effectiveness.

Finally, the Disseminate stage involved packaging the validated product and sharing it with mathematics teachers as a supplementary teaching resource for the topic of the Two-Variable Linear Equation System. The dissemination was conducted on a limited scale. The final product, comprising the five valid and reliable bilingual questions, was shared with mathematics teachers at the research location as an alternative teaching material.

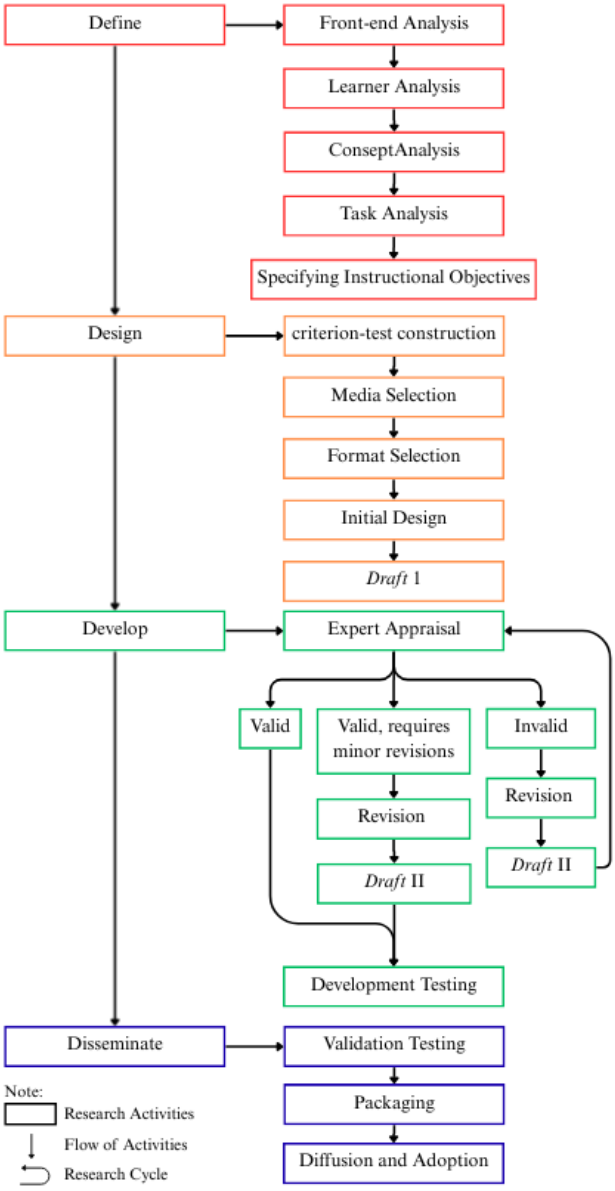

Figure 1. The Research Procedure Followed The 4-D Model Stages.

Data Collection and Analysis. Data were gathered through documentation, expert validation sheets, tests, and student questionnaires. The collected data were then analyzed to evaluate the product's validity, reliability, and effectiveness. Validity was assessed in two ways. Content validity was established using the Content Validity Index (CVI). Based on the ratings from three validators, both the Item-CVI (I-CVI) and the Scale-Level CVI (S-CVI/Ave) were calculated. An I-CVI value of ≥ 0.67 for each item and an S-CVI/Ave of ≥ 0.90 (for N=3) for the entire scale were considered indicators of excellent validity (Polit et al., 2007). Empirical validity (construct validity) was tested by correlating each item's score with the total test score using the Pearson Product-Moment

correlation in SPSS Statistics 27. An item was deemed valid if the correlation was significant ($p < 0.05$) and the calculated r-value exceeded the critical r-table value of 0.396 (for N=25).

Reliability for the essay test was measured for internal consistency using Cronbach's Alpha. The analysis was performed with SPSS Statistics 27, and a coefficient value greater than 0.70 was interpreted as indicating high reliability (Tavakol & Dennick, 2011). Effectiveness was measured from two perspectives. First, learning outcomes were analyzed by calculating the percentage of students who met or exceeded the Minimum Mastery Criteria (KKM) of 76. The product was considered effective if at least 75% of the class achieved mastery. Second, student responses from the questionnaire were analyzed descriptively. The combined percentage of students who selected "Agree" and "Strongly Agree" on positive statements regarding the questions' readability, benefits, and attractiveness was calculated to gauge acceptance.

RESULTS AND DISCUSSION

The development process successfully produced a set of five bilingual essay questions on the topic of the Two-Variable Linear Equation System, each contextualized within the local wisdom of Sidoarjo, including Reog Cemandi (Supriyadi, 2024), Banjar Kemuning Dance (Wowiling, 2024), Woven Craft (Ikromah, 2025), and Petis (Ikromah, 2025). The 4-D model provided a systematic framework for this development, ensuring the product was grounded in analysis and iterative refinement. The Define stage confirmed the need for contextual and bilingual learning materials, which aligns with the principles of Culturally Relevant Pedagogy that advocate for leveraging students' cultural knowledge to enhance engagement and understanding. Based on the results of interviews with teachers and a review of the literature, several fundamental problems were identified in the teaching and learning of mathematics, specifically in the topic of Systems of Linear Equations in Two Variables. These issues are related to the perceived abstract nature of the material, monotonous problems, a lack of relevance to daily life, and minimal integration of local cultural contexts and global demands. Therefore, an innovative solution is required in the form of developing mathematics problems based on Sidoarjo's local wisdom in a bilingual format. This is particularly relevant for Grade IX students at Sepuluh Nopember Junior High School, a bilingual school, who require more meaningful and engaging problems to master Two-Variable Linear Equation System concepts. The stage specifically defined the following development targets: 1) creating bilingual problems rooted in Sidoarjo’s local wisdom, 2) aligning questions with the Merdeka Curriculum learning objectives, 3) supporting students' formal operational cognitive stage

by providing real-world contexts, and 4) leveraging the school's bilingual environment to enhance mathematical literacy in both Indonesian and English.

Based on a systematic analysis of learning objectives and local context, the Design stage successfully translated the foundational needs identified in the Define stage into a concrete and validated product blueprint. The primary outcome was a test grid that mapped five bilingual essay questions. Furthermore, the development of detailed Learning Flow Objectives and Competency Achievement Indicators provided a critical framework to guarantee each question aligns with curriculum goals, from identifying variables to interpreting solutions, thereby establishing strong construct validity (Kristanto et al., 2022). Strategic decisions on medium (hardcopy) and format (Indonesian text followed by English translation) were made to ensure practicality, accessibility, and support for bilingual literacy in a classroom setting. Consequently, this stage did not merely produce a list of questions but a coherent instructional design where local context is not a superficial addition but the core vehicle for achieving targeted mathematical reasoning and problem-solving skills.

The expert validation process yielded strong evidence for the content validity of the questions. The quantitative analysis using the Content Validity Index (CVI) showed excellent results. The result of Scale-Content Validity Index/Average (S-CVI/Ave) presented in Table 1 for all five questions was 0.96, which is well above the 0.90 threshold for high content validity (Polit et al., 2007). Qualitatively, validators provided constructive feedback, primarily on refining instructional verbs in the questions' prompts to better elicit detailed answers. These suggestions were incorporated into the final product.

Table 1. Results of Scale-Content Validity Index/Average (S-CVI/Ave) for Each Question Item

Question Item	S-CVI/Ave	Validity
Item 1	0,96	Valid
Item 2	0,96	Valid
Item 3	0,96	Valid
Item 4	0,96	Valid
Item 5	0,96	Valid

Furthermore, empirical validity was tested using Pearson Product-Moment correlation with data from 25 students. The results, presented in Table 2, confirmed that all five question items were valid. The correlation coefficient (r-count) for each item significantly exceeded the r-table value of 0.396 ($p < 0.05$).

Table 2. Results of Empirical Validity Test for Each Question Item

Question Item	r-count	r-table	Sig. (2-tailed)	Validity
Item 1	0,819	0,396	0,001	Valid
Item 2	0,891	0,396	0,001	Valid
Item 3	0,788	0,396	0,001	Valid
Item 4	0,692	0,396	0,001	Valid
Item 5	0,874	0,396	0,001	Valid

The high validity scores indicate that the questions accurately measured the intended Two-Variable Linear Equation System competencies and that the integration of local contexts and bilingual presentation did not compromise their construct validity. This finding aligns with research by Nisa (2021), who also developed valid math questions using Sidoarjo's local wisdom, though focused on geometry. The present study extends this finding by demonstrating that validity can be successfully maintained in the more complex format of bilingual essay questions for algebra topics.

The reliability of the five-item test was assessed using Cronbach's Alpha. The analysis resulted in a high coefficient of 0.855. According to Jum Nunnally's (1978) reliability criterion in (Lance et al., 2006), an instrument is considered reliable if its alpha value exceeds 0.70. Therefore, the developed test instrument has an excellent level of internal consistency and is suitable for use in research. The Cronbach’s Alpha reliability test was chosen because the instrument consists of essay-type questions, with each item’s score falling within the same range (0–20). According to Arikunto (2019), Cronbach’s Alpha is appropriate for testing the reliability of instruments with continuous or scale-range scores, and it can measure consistency among items within a single test. Thus, this reliability calculation result indicates that the five essay items consistently measure students' competence in the Two-Variable Linear Equation System material.

The effectiveness of the questions was evaluated through student learning outcomes and their responses to a questionnaire. The test results showed that 19 out of 25 students (76%) achieved scores above the school's Minimum Mastery Criteria (MMC) of 76. This met the requirement for classical learning completeness (≥75%), indicating that the questions were effective in facilitating student learning on the topic (Sriyanti, 2023). Student responses, gathered via a questionnaire, further reinforced the product's effectiveness. A large majority of students responded positively ("Agree" or "Strongly Agree") regarding the integration of local wisdom. For instance, 87% reported that the local context made them more interested in working on the test, and 88% felt that it helped them understand the material better. Similarly, for the bilingual aspect, 84% of students stated that the bilingual format did not hinder their understanding, and 84% expressed a desire for more bilingual questions to prepare for global challenges.

A primary strength of this study is its successful fusion of local wisdom with bilingual education within a rigorous R&D framework, resulting in an assessment tool that is both culturally relevant and globally minded. The use of essay questions is another strength, as it allows for a deeper assessment of problem-solving and communication skills compared to multiple-choice formats.

However, the study is not without its weaknesses. The expert validation initially highlighted a weakness in the phrasing of question prompts, which was a crucial revision. Furthermore, while the majority of students responded positively, a minority (approximately 16%) reported difficulties with the bilingual text or local terms, indicating that such materials may require additional scaffolding for some learners.

The main limitations of this research concern its scope and generalizability. The development and testing were confined to a single school with a relatively small sample size of 25 students. Consequently, the findings, while highly promising, may not be fully representative of a broader student population. Future research should involve larger-scale trials across diverse educational settings and include a more extensive dissemination phase to validate the widespread applicability and impact of the developed questions.

CONCLUSION

Based on the results and discussion, the following conclusions can be drawn:

1. The development process using the 4-D model (Define, Design, Develop, Disseminate) successfully produced a set of five bilingual (Indonesian-English) mathematics essay questions on the topic of the Two-Variable Linear Equation System, which are integrated with the local wisdom contexts of Sidoarjo, namely Reog Cemandi, Banjar Kemuning Dance, Woven Crafts, and Petis.
2. The developed bilingual mathematics questions have proven to be valid based on both expert judgment and empirical testing. Expert validation resulted in an excellent Scale-Content Validity Index/Average (S-CVI/Ave) of 0.96. Furthermore, all question items were declared empirically valid with a correlation coefficient (r-count) > r-table (0.396) and a significance value (p) < 0.05.
3. The set of five questions has proven to be reliable, as indicated by a high Cronbach's Alpha coefficient of 0.855. This confirms that the instrument consistently measures students' understanding of Two-Variable Linear Equation System. The developed questions have proven to be effective based on student learning outcomes and their responses. Learning outcomes showed that 76% of students achieved the Minimum Mastery Criteria (MMC), thus fulfilling the requirement for classical mastery. Student questionnaire responses also indicated very positive acceptance towards both the local wisdom context and the bilingual format of the questions.

Suggestions for Further Development. The results of this study open up opportunities for further development and application:

1. Wider Application: It is recommended to implement these questions in a broader context, not limited to the research school, to test their practicality and effectiveness on a larger scale.
2. Digital Format Development: Subsequent development could focus on converting these questions into digital interactive formats or integrating them into e-learning platforms to enhance accessibility and student engagement.
3. Expansion to Other Topics: The development model of integrating local wisdom and bilingualism can be applied to other mathematical topics or even different subjects, exploring new local contexts to enrich learning resources.

Longitudinal Research: Future research could investigate the long-term impact of using such questions on students' mathematical reasoning abilities and cultural awareness.

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