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DEVELOPMENT AND VALIDATION OF AN ALGEBRA LITERACY TEST INTEGRATED WITH CHARACTER EDUCATION FOR ASSESSING MATHEMATICAL REASONING ABILITIES

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Abstrak

Penalaran matematis telah diakui sebagai salah satu keterampilan penting dalam pembelajaran matematika. Penilaian keterampilan ini memerlukan instrumen evaluasi yang terstruktur untuk memastikan akurasi pengukuran. Penelitian ini bertujuan untuk mengembangkan instrumen penilaian literasi aljabar yang diintegrasikan dengan penguatan pendidikan karakter untuk mengevaluasi kemampuan penalaran matematis siswa. Dengan menggunakan pendekatan penelitian berbasis desain melalui model Formative Research (Tessmer), penelitian ini melibatkan mahasiswa S1 yang terdaftar di Program Studi Pendidikan Matematika Universitas Islam Negeri (UIN) Alauddin Makassar. Instrumen penelitian yang digunakan meliputi asesmen literasi aljabar, lembar validasi, dan angket respon mahasiswa. Analisis data dilakukan untuk mengetahui validitas, reliabilitas, tingkat kesukaran butir soal, daya pembeda, dan kepraktisan butir soal. Proses penelitian dan pengembangan berujung pada instrumen penilaian literasi aljabar sebanyak 30 butir soal yang telah divalidasi dan diintegrasikan dengan penguatan pendidikan karakter, yang menunjukkan sifat psikometrik yang baik. Temuan menunjukkan bahwa instrumen yang dikembangkan merupakan alat yang valid dan dapat diandalkan untuk menilai kemampuan penalaran matematis dalam konteks pendidikan tinggi.

Kata kunci: Literasi Aljabar; Penalaran Matematis; Penguatan Pendidikan Karakter; Instrumen Penilaian; Pendidikan Tinggi

Abstract

Mathematical reasoning has been recognized as one of the important skills in mathematics learning. The assessment of this cognitive skill necessitates a robust and well-structured evaluation instrument to ensure accurate measurement. This study aims to develop an algebra literacy assessment instrument integrated with character education reinforcement to evaluate students' mathematical reasoning abilities. Adopting a design-based research approach through the Formative Research model (Tessmer), this study involves undergraduate students enrolled in the Mathematics Education Program at Universitas Islam Negeri (UIN) Alauddin Makassar. The research instruments include the algebra literacy assessment, validation sheets, and student response questionnaires. Data analysis is conducted to determine the validity, reliability, item difficulty level, discriminatory power, and practicality

of the test items. The research and development process culminated in a validated 30-item algebra literacy assessment instrument integrated with character education reinforcement, demonstrating robust psychometric properties. The findings indicate that the developed instrument is a valid and reliable tool for assessing mathematical reasoning skills in higher education contexts.

Keywords: Algebra Literacy; Mathematical Reasoning; Character Education Reinforcement; Assessment Instrument; Higher Education

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INTRODUCTION

Mathematics education plays a crucial role in students' cognitive development, as mathematical concepts are intricately linked to various aspects of everyday life (Suhaeni et al., 2023; Widia et al., 2024; Abbas et al., 2025). Therefore, learning mathematics is one of the mandatory components of education for students at all levels (Sabar et al., 2023; Amin et al., 2024). In the process of learning mathematics, there are several cognitive abilities that are developed as part of high-level thinking skills, one of which is reasoning ability, commonly referred to as mathematical reasoning (Martani & Murtiyasa, 2016; Lutfi et al., 2021; Nur et al., 2024). Mathematical reasoning is an analytical activity that relies on a logical and systematic thought process to draw conclusions from existing information (Merona & Santi, 2018). As Saraswati et al., (2023) assert, a strong mathematical reasoning ability significantly enhances mathematical literacy by enabling students to analyze relationships, identify patterns, and construct valid arguments within mathematical contexts.

The significance of algebra literacy in the development of mathematical reasoning cannot be overstated. Algebra serves as a gateway to advanced mathematical concepts, providing students with the tools necessary for abstract thinking and problem-solving. According to Kieran (2018), algebra literacy encompasses the ability to understand algebraic symbols, manipulate expressions,

and apply algebraic concepts to solve problems in various contexts. This form of literacy is not merely about computational skills but also about developing a deeper conceptual understanding that supports mathematical reasoning processes. Johar & Yusniarti (2018) further emphasize that strong algebra literacy contributes significantly to students' capacity for logical deduction, inductive reasoning, and pattern recognition—all essential components of mathematical reasoning.

Character education, meanwhile, plays a complementary role in fostering mathematical reasoning by developing essential attributes such as perseverance, integrity, and critical thinking. In the context of developing assessment instruments, strengthening these attributes can be integrated to evaluate not only mathematical cognitive abilities, but also how students apply character values in the process of solving complex mathematical problems. As noted by Budiarto (2016), mathematics education holds significant potential for character development, as the values embedded in mathematical learning foster personal and ethical qualities. Komalasari & Saripudin (2018) observe that character education within mathematics instruction encourages students to approach problems with honesty, diligence, and intellectual curiosity. These character traits are not merely incidental to mathematical learning but are integral to the development of robust reasoning skills. When students possess qualities such as persistence and intellectual honesty, they are better equipped to engage in sustained mathematical reasoning and critically evaluate their conclusions.

Empirical data indicate that Indonesia's mathematical literacy remains at a low level, which in turn affects students' mathematical reasoning skills. In 2022, Indonesia's PISA mathematics score was recorded at 366, marking a significant decline from the 2018 score of 379 (OECD, 2023). This performance places Indonesia well below the OECD average, indicating substantial challenges in mathematical education. The low performance in PISA mathematics assessments is closely linked to deficiencies in mathematical reasoning (Ariati & Juandi, 2022). This is because mathematical literacy is an individual's capacity to formulate, use

and interpret mathematics in various contexts. This includes mathematical reasoning and the use of mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena (Amin et al., 2023). According to Stacey & Turner (2015) mathematical problems in PISA assessments predominantly evaluate reasoning, problem-solving, and argumentation skills, rather than focusing on technical abilities such as memorization and basic calculations. This emphasis highlights the critical importance of developing students' reasoning abilities as a foundation for mathematical literacy.

One of the primary challenges faced by educators is the limited availability of well-designed assessment items tailored to students' potential and characteristics. This research contributes to overcoming these challenges by developing a more relevant and effective assessment instrument, which can explore students' mathematical reasoning potential more accurately and comprehensively. Anggara & Abdillah (2023) highlight that many educators still lack the necessary skills in developing effective assessment instruments, including designing evaluations, constructing test items, developing scoring rubrics, and formulating assessment guidelines. This deficiency is particularly problematic in the Indonesian educational context, where standardized assessments may not adequately capture the nuances of students' mathematical reasoning abilities or account for the cultural and educational context in which learning occurs. Consequently, students' potential in employing reasoning to solve mathematical problems has not been fully optimized, leading to persistent challenges in mathematical achievement.

One proposed solution to address this issue is to integrate algebra literacy as a core component of mathematical literacy. Strengthening algebra literacy is a strategic approach, as it not only deepens students' understanding of algebraic concepts but also plays a pivotal role in improving mathematical reasoning skills. However, efforts to enhance reasoning ability must also consider other contributing factors, such as the quality of students' character development. Weak character traits, such as low integrity, perseverance, and collaboration, may hinder progress

in mathematical reasoning. Therefore, alongside algebra literacy, character education must be emphasized as an essential aspect of students' holistic development. Based on this, the purpose of this study is to develop an algebraic literacy assessment instrument that can evaluate students' mathematical reasoning skills, while considering the role of character education in improving these abilities.

The development of an algebra literacy test integrated with character education presents a compelling solution to address the challenges associated with assessing mathematical reasoning. Several previous studies have explored the development of assessment instruments related to mathematical reasoning, including those by Lutfi et al. (2021), Nurhasanah (2018), Merona & Santi (2018), Rosalina & Elly S (2018), and Martani & Murtiyasa (2016). These studies primarily focused on designing tests to evaluate students' mathematical reasoning skills. Additionally, research by Wahyudi et al. (2021) examined the integration of character values in mathematics learning. However, despite the existence of prior research on both mathematical reasoning assessment and character education in mathematics, a significant gap remains in the development of algebra literacy tests explicitly incorporating character education.

The urgency of this research is further substantiated by literature reviews and observations within the Mathematics Education Program at UIN Alauddin Makassar, where no similar test instrument has been developed. Therefore, creating an algebra literacy test that is integrated with character education to assess students' mathematical reasoning is of paramount importance. This instrument is expected not only to serve as a tool for evaluating students' conceptual understanding and reasoning skills but also to provide a structured platform for cultivating essential character traits among students.

METHOD

This study employed a Research and Development (R&D) approach to develop a standardized algebra literacy test integrated with character education, designed to measure students' mathematical reasoning abilities. The R&D approach

was chosen because it provides a systematic method for creating and validating educational tools that are directly applied in real classroom contexts. By using this approach, this research ensures that the developed instruments meet the practical needs of educators and students. The development process followed Tessmer's Formative Research model, which was chosen for its structured and iterative nature, allowing for continuous improvement based on feedback. The Tessmer model consists of several systematic stages: (1) Preliminary stage, (2) Self-evaluation, (3) Formative evaluation (prototyping) including expert reviews, one-to-one trials, and small-group trials, and (4) Field testing.

This study was conducted at the Mathematics Education Program of Universitas Islam Negeri (UIN) Alauddin Makassar, Indonesia. The participants were undergraduate students from this program, specifically from the 2020 and 2022 cohorts. These cohorts were selected based on their exposure to algebra courses and their diverse academic backgrounds, ensuring a representative sample for testing the instrument's effectiveness across different proficiency levels. Instrument testing was conducted in three stages, namely: one-to-one test with 3 participants, small group test with 6 participants, and field test with 10 participants.

A mixed-methods approach was utilized to comprehensively evaluate the algebra literacy test, integrating both qualitative and quantitative research methods. Qualitative data were collected through expert reviews and student feedback during the one-to-one and small-group trials. The qualitative data were analyzed using thematic analysis, with key themes and patterns identified across different sources of feedback. This analysis guided the refinement of test items and informed decisions regarding their revision or replacement.

Quantitative data were collected through validation forms, student questionnaires, and test scores. The validation forms used a Yes/No scale, the student questionnaires employed a Likert scale, and the test featured an essay format. These data were analyzed using various statistical techniques to determine the instrument's psychometric properties. Content validity was assessed using the

Content Validity Ratio (CVR) and Content Validity Index (CVI) based on expert evaluations. Expert evaluation was conducted by involving two experts who have experience and knowledge in the field of mathematics education and assessment instrument development.

To ensure that the algebra literacy test was both valid and practical for classroom use, the following evaluation criteria were established:

Table 1. Criteria for Instrument Quality

Criterion	Definition	Acceptance Threshold
Content Validity (CVR & CVI)	Assessed the relevance and representativeness of test items	CVR and CVI ≥ 0.34
Practicality	Measured students' perceptions of ease of use and implementation	≥ 51% of students rated the test as "good"
Reliability	Determined the consistency of test scores across different administrations	≥ 0.61 (high category)
Item Difficulty	Ensured that test items were neither too easy nor too difficult	0.31 – 0.70 (moderate difficulty)
Item Discrimination	Evaluated whether the test effectively distinguished high- and low-performing students	> 0.2 (sufficient discrimination)

RESULT AND DISCUSSION

The process of developing the algebra literacy test integrated with character education strengthening utilized the Formative Research development model (Tessmer), following the development procedure outlined below:

Preliminary Stage

The preliminary stage is the fundamental first step in the research process. In this phase, the researcher undertakes a comprehensive preliminary review by

systematically collecting and analysing relevant references that support and guide the ongoing study. The references gathered encompass a broad spectrum of interconnected aspects that collectively contribute to constructing the research framework. These aspects include the development model to be applied, the selection of appropriate test instruments, the concept of algebra literacy, and the integration of character education strengthening within the educational context.

Upon reviewing a wide array of scholarly references, the researcher identifies the Formative Research model developed by Tessmer as an optimal framework for instrument development. The model is particularly valued for its systematic and rigorous approach, which ensures that the instrument undergoes a thorough validation and refinement process to meet the necessary standards of validity and reliability. By adopting the Formative Research model, the researcher aspires to develop a test instrument that not only provides accurate measurements of students' mathematical reasoning abilities but also aligns with the broader educational goals of fostering character education and enhancing algebra literacy.

Self-Evaluation Stage

The self-evaluation stage constitutes the second phase in the development of an integrated algebra literacy test aimed at reinforcing character education, utilizing the Formative Research model developed by Tessmer. In this phase, the researcher independently designs an algebra literacy test instrument that also incorporates elements of character education. The primary objective of this instrument is to assess students' mathematical reasoning abilities. The designed instruments include test blueprints, test items, answer keys, and scoring guidelines, which are intended to provide a structured and comprehensive tool to evaluate students' mathematical reasoning ability. This self-evaluation stage is divided into two major components: the analysis phase and the design phase.

1. **Analysis Phase**

The analysis phase consists of three key activities: curriculum analysis, student analysis, and material analysis.

Curriculum Analysis

Curriculum analysis is conducted to gain a comprehensive understanding of the structure, objectives, and competencies outlined in the prevailing curriculum. The researcher examines various curricular components related to algebra literacy and character education, ensuring that they support the development of students' mathematical reasoning. The purpose of this analysis is to align the research objectives with curricular goals, thereby ensuring its relevance and contribution to educational advancements. At UIN Alauddin Makassar, the Mathematics Education program has incorporated mathematical literacy as a core component of its curriculum. Mathematical literacy is recognized as an essential skill that every graduate must possess, given its significance in understanding, analyzing, and solving mathematical problems in real-life contexts. One of the integral aspects of mathematical literacy is algebra literacy, which plays a crucial role in enhancing students' ability to think abstractly and logically. Algebra literacy extends beyond merely understanding symbols and algebraic operations; it also involves the ability to apply algebraic concepts across various academic and practical contexts.

Student Analysis

Student analysis aims to identify the characteristics, needs, and proficiency levels of the research participants. Understanding students' diverse backgrounds and competencies allows the researcher to design an instrument that effectively assesses algebra literacy and mathematical reasoning skills. The findings from this analysis reveal variations in students' abilities, leading to the formation of three distinct research groups: one-to-one testing, small group testing, and field testing.

Material Analysis

Material analysis focuses on evaluating and selecting algebraic content that aligns with the study's objectives. The researcher carefully examines the mathematical topics that will serve as the foundation for the test development, ensuring that they not only adhere to the curriculum but also present sufficient cognitive challenges to assess students' mathematical reasoning. This analysis

involves identifying essential algebraic concepts and exploring how they can be integrated with character education reinforcement. The key algebraic topics selected for this study include: 1) systems of linear equations; 2) sequences and series; 3) principle of inclusion and exclusion in set theory; 4) systems of inequalities; 5) operations in algebra; 6) functions; and 7) ratios and proportions.

2. Design Phase

Following the completion of the analysis phase, the next step is the design phase. In this phase, the researcher develops the test instrument, which consists of test blueprints, open-ended test items, answer keys, and scoring rubrics. The initial design of the test instrument is structured to ensure that the items effectively measure students' algebra literacy and mathematical reasoning skills while simultaneously embedding elements of character education.

The test blueprint was developed based on the curriculum and material analyses, specifying the algebraic concepts to be assessed, the cognitive levels targeted (according to Bloom's taxonomy), and the character values to be reinforced. The test items were created as open-ended questions that required students to demonstrate their reasoning processes rather than simply providing final answers. This format allowed for a deeper assessment of students' thinking strategies and their ability to construct valid mathematical arguments. Answer keys and scoring rubrics were developed to ensure consistent and objective evaluation of students' responses. The validity of the assessment rubric and answer key was obtained through expert reviews that provided feedback and suggestions for improvement, which were then used to refine the instrument so that it was more accurate and relevant in measuring student abilities.

Prototyping Phase

The prototyping phase constitutes a critical stage in the development of the algebraic literacy test instrument, integrating character education reinforcement. At this stage, all research instruments that were initially developed and refined through self-evaluation in Prototype I undergo systematic evaluation. The test

instruments are subsequently administered to four testing groups: expert review, one-to-one, small group, and field testing. The outcomes of these evaluations serve as the foundation for iterative revisions to enhance the validity, reliability, and overall effectiveness of the instrument.

1. Expert Review Phase

The expert review phase involves a rigorous validation process wherein subject matter experts provide critical feedback on the initial test instrument design. In this study, the validators comprised two faculty members from the Mathematics Education Department at UIN Alauddin Makassar, whose expertise was instrumental in assessing the content validity of the instrument.

The content validity of the test instrument was assessed through expert review by two faculty members from the Mathematics Education Department at UIN Alauddin Makassar. The validation results are presented in Table 2.

Table 2. Content Validity of the Test Instrument

Average CVR Score	CVI	Classification
1.0	1.0	Items Support Validity

The Content Validity Ratio (CVR) and Content Validity Index (CVI) both achieved perfect scores of 1.0, indicating unanimous expert agreement on the relevance and appropriateness of all 30 test items. This robust validation confirms that the instrument effectively captures the intended constructs and aligns with the educational objectives of both algebra literacy and character education integration.

2. One-to-One Phase

The one-to-one phase entails an individualized assessment process, wherein the test instrument is administered to three undergraduate students from the Mathematics Education Department. The selection of these participants was based on their varying proficiency levels to evaluate the readability, clarity, and cognitive load of the test items. Upon completion of the test, students were required to complete a structured questionnaire designed to elicit feedback regarding the linguistic clarity, level of difficulty, and overall feasibility of the instrument. The

qualitative insights gained from this phase informed necessary refinements to enhance the test's effectiveness. A key concern identified during this phase was the time allocation for test completion. The students reported experiencing difficulty in adequately responding to all items within the initially allocated time frame. In response to this issue, the researcher implemented an extension of the test duration to allow participants to engage more comprehensively with the tasks. Following these modifications, the refined version of the test instrument is designated as Prototype II, which incorporates the necessary adjustments to enhance validity, usability, and practicality in subsequent testing phases.

3. Small Group Phase

The small group phase involves testing the instrument in a small group setting, consisting of six undergraduate students from the Mathematics Education Department. This group was selected with reference to the high, low, medium ability levels of the research subjects. This phase provides an opportunity for the researcher to observe how participants interact with the algebraic literacy test instrument and identify potential difficulties or obstacles that may not have been detected during the one-to-one phase. During this phase, the six students actively engaged with the test instrument that had been previously designed. Following the completion of the test, each student was required to fill out a questionnaire designed to gather feedback on various aspects of the instrument, including: 1) the difficulty level of the items; 2) the clarity of instructions; 3) the relevance of the material; and 4) the time constraints provided for completing the test. Additionally, students were encouraged to provide more specific comments and suggestions regarding the instrument. These responses offered valuable insights that aided the researcher in evaluating the effectiveness and usability of the instrument. Based on the revisions made from this phase, the updated version of the instrument was labeled Prototype III, which was then tested in the subsequent field test phase.

4. Field Test Phase

The results from Prototype III were then tested in a field test conducted with students from the Mathematics Education Department at UIN Alauddin Makassar. This phase was carried out in a single session, where students were asked to complete a total of 30 open-ended questions, which had been divided into three sets of questions. Each set of questions was allocated 120 minutes for completion, ensuring that students had adequate time to understand and respond thoroughly to each question. At the end of the field test, the researcher administered another questionnaire to evaluate the practicality of the developed instrument. The purpose of the questionnaire was to collect feedback from students regarding their experience while completing the test, including aspects such as: 1) clarity of the questions; 2) suitability of the allotted time; and 3) comfort and ease of use of the instrument.

The practicality of the test instrument was evaluated through student feedback during the field test phase. Students completed a structured questionnaire addressing various aspects of the instrument's usability and engagement. The results are presented in Table 3.

Table 3. Field Test Student Questionnaire Results

Indicator	Percentage (%)
Content Quality	89.78
Clarity	85.56
Engagement	84.33
Ease of Use	88.67
Average	87.08

The questionnaire results demonstrate consistently positive student evaluations across all indicators. Content quality received the highest rating (89.78%), followed by ease of use (88.67%), clarity (85.56%), and engagement (84.33%). The overall average of 87.08% places the instrument in the "Very Good" category for practicality, confirming that it is user-friendly, engaging, and

effectively designed from the student perspective. These findings suggest that the integration of character education elements did not compromise the accessibility or clarity of the algebraic content. Thus, this instrument can be effectively applied in the classroom, providing teachers with a practical and structured tool to thoroughly measure students' mathematical reasoning while reinforcing character values.

Reliability Analysis

Reliability assessment was conducted to determine the internal consistency of the test items across all three test packages. Cronbach's alpha coefficients were calculated for each package, with results presented in Table 4.

Table 4. Reliability of the Test Instrument

Package	r_{11}	Category
A	0.85	Very High
B	0.89	Very High
C	0.91	Very High

The Cronbach's alpha coefficients for all three packages (A = 0.85, B = 0.89, C = 0.91) fall within the "Very High" reliability range (0.81-1.00). These strong reliability values indicate exceptional internal consistency, demonstrating that the test instrument consistently measures algebraic literacy and mathematical reasoning with minimal measurement error. The high reliability coefficients across all packages confirm the instrument's stability and dependability for educational assessment purposes.

Item Difficulty Analysis

To ensure the test items provided appropriate challenge levels for the target population, the difficulty level of each item was analyzed. Results for each package A (PA), package B (PB), and package C (PC) are presented in Table 5

Table 5. Difficulty Level Test

Item Number	Difficulty Level			Category		
	PA	PB	PC	PA	PB	PC
1	0.70	0.70	0.70	Moderate	Moderate	Moderate
2	0.68	0.70	0.70	Moderate	Moderate	Moderate
3	0.73	0.65	0.67	Easy	Moderate	Moderate

Item Number	Difficulty Level			Category		
	PA	PB	PC	PA	PB	PC
4	0.82	0.70	0.69	Easy	Moderate	Moderate
5	0.70	0.52	0.69	Moderate	Moderate	Moderate
6	0.63	0.65	0.67	Moderate	Moderate	Moderate
7	0.70	0.66	0.70	Moderate	Moderate	Moderate
8	0.62	0.62	0.65	Moderate	Moderate	Moderate
9	0.63	0.60	0.57	Moderate	Moderate	Moderate
10	0.63	0.60	0.67	Moderate	Moderate	Moderate
Average	0.68	0,64	0.67	Moderate	Moderate	Moderate

Analysis of the difficulty indices reveals that most items across all three packages fall within the moderate difficulty range, with average difficulty levels of 0.68, 0.64, and 0.67 for Packages A, B, and C respectively. Package A contains two items (3 and 4) classified as "Easy" with indices of 0.73 and 0.82, while all items in Packages B and C maintain moderate difficulty levels consistently.

The moderate difficulty levels across all packages indicate that the test instrument is appropriately calibrated for the target population, neither too challenging nor too simple, making it effective for assessing students' algebraic literacy and mathematical reasoning abilities across varying proficiency levels. This well-balanced difficulty distribution enhances the instrument's diagnostic utility and ensures its applicability for a diverse student population.

Item Discrimination

The discrimination items index was analysed to determine how effectively they differentiate between high and low-performing students. The results for each package are presented in Table 6.

Table 6. Item Discrimination

Item Number	Item Discrimination			Category		
	PA	PB	PC	PA	PB	PC
1	0.30	0.26	0.33	Sufficient	Sufficient	Sufficient
2	0.35	0.28	0.33	Sufficient	Sufficient	Sufficient
3	0.21	0.21	0.28	Sufficient	Sufficient	Sufficient
4	0.06	0.30	0.28	Poor	Sufficient	Sufficient
5	0.26	0.41	0.41	Sufficient	Good	Good
6	0.31	0.55	0.65	Sufficient	Good	Good
7	0.38	0.46	0.33	Sufficient	Good	Sufficient
8	0.26	0.41	0.23	Sufficient	Good	Sufficient

Item Number	Item Discrimination			Category		
	PA	PB	PC	PA	PB	PC
9	0.43	0.40	0.21	Good	Sufficient	Sufficient
10	0.31	0.50	0.45	Sufficient	Good	Good
Average	0.29	0.38	0.35	Sufficient	Sufficient	Sufficient

The discriminatory power analysis reveals varying effectiveness across items and packages. Package A shows mostly sufficient discrimination (average = 0.29), with one item (Item 4) classified as "Poor" (0.06) and one item (Item 9) categorized as "Good" (0.43). Package B demonstrates stronger discrimination capacity (average = 0.38), with five items classified as "Good" (values ranging from 0.41 to 0.55). Package C shows moderate discrimination (average = 0.35), with three items in the "Good" category (values from 0.41 to 0.65).

The presence of items with "Good" discrimination, particularly in Packages B and C, indicates that the test effectively differentiates between varying levels of student ability in mathematical reasoning. This ability allows the instrument to play an important role in diagnosing learning, helping to identify strengths and areas for improvement in students. The identification of one item with "Poor" discrimination (Item 4 in Package A) provides valuable information for future refinement of the instrument. Overall, the sufficient discriminatory power across all packages confirms the instrument's capability to distinguish between students with different levels of algebraic reasoning abilities.

Mathematical Reasoning Ability Analysis

Students' mathematical reasoning abilities, as measured by the developed test instrument, were analyzed and categorized based on their test scores. Results for each package are presented in Tables 7-8.

Table 7. Analysis of Algebraic Literacy Test Results for Package A

Score Range	Frequency (F)	Percentage (%)	Category
81-100	3	30	High
61-80	4	40	Medium
0-60	3	30	Low
Total	10	100	
Average Score		68.25	Medium

Table 8. Analysis of Algebraic Literacy Test Results for Package B

Score Range	Frequency (F)	Percentage (%)	Category
81-100	4	40	High
61-80	1	10	Medium
0-60	5	50	Low
Total	10	100	
Average Score		64.42	Medium

Table 9. Analysis of Algebraic Literacy Test Results for Package C

Score Range	Frequency (F)	Percentage (%)	Category
81-100	4	40	High
61-80	2	20	Medium
0-60	4	40	Low
Total	10	100	
Average Score		67.33	Medium

The analysis of students' mathematical reasoning abilities reveals a distribution across all three performance categories with interesting patterns. In Package A, the distribution was relatively balanced (30% High, 40% Medium, 30% Low), with an average score of 68.25. Package B showed a more polarized distribution (40% High, 10% Medium, 50% Low), with an average score of 64.42. Package C demonstrated a similar pattern (40% High, 20% Medium, 40% Low), with an average score of 67.33.

Across all three packages, the average scores fall within the "Medium" category, indicating that students' algebraic reasoning abilities are at a moderate level. This finding suggests that while students have developed basic algebraic reasoning skills, there is still significant room for improvement in their ability to apply algebraic concepts to solve complex problems and construct valid mathematical arguments. The substantial proportions of students in both the "High" and "Low" categories across all packages highlight the diverse proficiency levels within the student population and the need for differentiated instructional approaches.

The development of an algebra literacy test integrated with character education reinforcement followed a systematic and iterative process using Tessmer's Formative Research model. This model proved exceptionally effective for developing the instrument due to its comprehensive approach to validation and refinement through multiple stages.

The effectiveness of Tessmer's model in this study aligns with findings from previous research. Arif et al. (2022) reported that the Formative Research model facilitated systematic development and validation of mathematical assessment instruments through its iterative approach. Similarly, Jumrah et al. (2023) found that the model's structured validation process contributed to enhanced instrument quality. The multiple evaluation phases in Tessmer's model allowed for continuous refinement based on empirical feedback from diverse stakeholders, resulting in a high-quality instrument that effectively integrates algebraic literacy assessment with character education reinforcement. In addition, Amin et al. (2025) research revealed that the Tessmer model allows testing and improving instruments at every stage, from initial design to final evaluation. Using this approach, the validation and revision process can be carried out systematically through trials, feedback analysis, and continuous improvement, so that the resulting instrument is more effective and in accordance with the measurement objectives.

While other development models such as the Plomp development model (Ayasa et al., 2023; Dewi & Defitriani, 2024), the ADDIE development model (Hariono et al., 2021; Aulia & Mutaqin, 2022; Lukman et al., 2023; Majid et al., 2024), and the 4D model (Putri et al., 2023; Mania et al., 2024) have been successfully used in the context of educational product development. Tessmer's model was particularly suitable for this study due to its emphasis on formative evaluation and its structured approach to validation through multiple testing phases. The model's progressive resistance approach, wherein modifications are made at stages with greater flexibility before reaching more rigid validation phases, allowed for systematic improvement of the instrument throughout the development process.

A significant contribution of this study is the successful integration of character education principles within an algebraic literacy assessment framework. Each test item was carefully designed to incorporate character values such as integrity, responsibility, collaboration, and perseverance while simultaneously assessing mathematical reasoning abilities. This integration was achieved through contextualizing algebraic problems within scenarios that naturally evoked character values, rather than artificially appending character education as a separate component.

This successful integration demonstrates that assessment instruments can serve dual purposes: evaluating cognitive abilities while reinforcing character values. As Wulansari et al. (2023) noted, education should aim to produce graduates who are not only intellectually capable but also possess strong character. The developed instrument contributes to this goal by providing a structured platform for assessing and developing both dimensions simultaneously.

The integration approach used in this study differs from traditional character education methods that treat character development as separate from academic content. Instead, it embeds character values within the context of algebraic problem-solving, making character education an integral part of mathematical reasoning. This approach is consistent in that embedding character values within mathematical instruction can enhance students' engagement with mathematical concepts and foster a deeper appreciation for the ethical dimensions of mathematical reasoning.

The instrument's excellent psychometric properties support its effectiveness as a tool for assessing algebraic literacy and mathematical reasoning while reinforcing character education. These findings align with results from similar studies in mathematics education. Pradipta et al. (2020) developed a valid and reliable instrument for measuring creative thinking and mathematical literacy with comparable psychometric properties. Similarly, Febriano et al. (2021) created a test of mathematical critical thinking that demonstrated strong validity and reliability.

The consistent findings across these studies suggest that carefully designed assessment instruments can effectively measure complex mathematical constructs when developed through rigorous methodological approaches.

The pattern of student performance observed in this study suggests that algebraic reasoning abilities develop unevenly across student populations. This finding has important implications for instructional design and curriculum development, as it indicates the need for differentiated approaches that address the diverse needs of students at different proficiency levels. The integrated assessment instrument developed in this study could serve as a valuable diagnostic tool for identifying specific areas of strength and weakness in students' algebraic reasoning, informing more targeted instructional interventions.

Limitations of the study: The study primarily focused on the development and validation of the assessment instrument rather than its implementation in regular classroom practice. As such, the long-term effects of using this integrated approach on students' mathematical reasoning abilities and character development remain to be investigated. Additionally, while the instrument integrated character education principles, the extent to which students internalized these principles during the assessment process was not directly measured. Another limitation is the focus on algebraic content to the exclusion of other mathematical domains. The test instrument was developed specifically for the algebraic domain of mathematics, and the applicability of the integrated assessment approach to other mathematical domains (e.g., geometry, statistics) or other academic disciplines remains an open question.

Based on the findings of this study, several recommendations can be offered for educational practice to enhance the assessment and development of algebraic literacy and character education: The developed instrument should be integrated into a comprehensive assessment system that includes both formative and summative evaluations of students' algebraic reasoning abilities and character development. This would provide a more complete picture of student growth over

time. Educational institutions should provide professional development opportunities for teachers to understand the theoretical foundations and practical applications of integrated algebraic literacy and character education assessment. This includes training in the administration, scoring, and interpretation of the instrument.

CONCLUSION

The outcomes of this research and development process resulted in the creation of 30 algebra literacy test items integrated with character education reinforcement. These test items have successfully met several key criteria: validity, reliability, appropriate difficulty level, sufficient discrimination power, and high practicality. The instrument demonstrates robust psychometric properties, with content validity indices of 1.0, reliability coefficients ranging from 0.85 to 0.91, moderate difficulty levels averaging between 0.64 and 0.68, and sufficient discriminatory power across most items.

The integrated approach to assessing algebraic literacy while reinforcing character education represents a significant contribution to both mathematics education and character development. By embedding character values such as integrity, perseverance, collaboration, and responsibility within algebraic problem-solving contexts, the instrument provides a structured platform for holistic student development. The positive student responses to the instrument, as evidenced by the high practicality ratings (average of 87.08%), suggest that this integrated approach is both practical and well-received by the target population.

The analysis of students' mathematical reasoning abilities revealed a medium level of performance across all three test packages, indicating that while students have developed basic algebraic reasoning skills, there is still significant room for improvement. The substantial percentages of students in both the "High" and "Low" categories underscore the need for differentiated instructional approaches that cater to the diverse needs of students at varying proficiency levels.

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