JARME Journal of Authentic Research on Mathematics Education
Volume 8, No. 8, January 2026
https://doi.org/10.37058/jarme.v3i1.17868 e-ISSN 2655-7762

HOW MINIMUM COMPETENCY–ORIENTED GEOMETRY INSTRUCTION SUPPORTS STUDENTS' MATHEMATICAL LITERACY: INSIGHTS FROM A DESIGN-BASED STUDY

Ipah Muzdalipah [1]*, Edi Hidayat [2], Ratna Rustina [3], Dwi Kurniasih [4]
(Universitas Siliwangi, Jl. Siliwangi no. 24 Kota Tasikmalaya 46115, Indonesia)
Email: ipahmuzdalipah@unsil.ac.id

ARTICLE INFO

Article history
Received: 2026-01-01
Revised: 2026-01-19
Accepted: 2026-01-30

Keywords
Instructional material, ADDIE, Mathematical literacy.

ABSTRACT

Penelitian ini bertujuan mengembangkan bahan ajar geometri berbasis Asesmen Kompetensi Minimum (AKM) untuk mendukung literasi matematis siswa SMP, khususnya pada proses *formulate–employ–interpret*. Penelitian menggunakan metode Research and Development (R&D) dengan model ADDIE yang meliputi tahap analisis, desain, pengembangan, implementasi, dan evaluasi. Tahap analisis menunjukkan adanya kesenjangan pembelajaran berupa dominasi pendekatan prosedural, keterbatasan media visual dan kontekstual, serta kesulitan siswa dalam menafsirkan masalah geometri kontekstual. Bahan ajar dikembangkan dengan pendahuluan kontekstual, visualisasi konsep, soal-soal berbasis AKM, kegiatan refleksi, dan penyajian jaring-jaring bangun ruang. Validitas produk dinilai oleh ahli materi dan ahli media mencakup kualitas isi dan tujuan, instruksional, serta teknis, dengan rata-rata skor 74,3% (kategori valid). Uji kepraktisan pada 25 siswa kelas VIII menunjukkan persentase 77%–79%, sehingga bahan ajar dinyatakan layak dan praktis digunakan dalam pembelajaran. Penelitian selanjutnya direkomendasikan untuk menguji keefektifan bahan ajar melalui desain eksperimen dan memperluas pengembangan media interaktif.

This study aimed to develop Minimum Competency Assessment (MCA)-based geometry instructional materials to support junior high school students' mathematical literacy, particularly in the formulate–employ–interpret process. The research employed a Research and Development (R&D) method using the ADDIE model, which consists of the stages of analysis, design, development, implementation, and evaluation. The analysis stage revealed learning gaps, including the dominance of procedural approaches, limited use of visual and contextual media, and students' difficulties in interpreting contextual geometry problems. The instructional materials were developed with contextual introductions, concept visualizations, AKM-based tasks, reflection activities, and geometric nets. Product validity was assessed by a content expert and a media expert, covering content and objective quality, instructional quality, and technical quality, with an average score of 74.3% (valid category). Practicality testing involving 25 eighth-grade students showed percentages ranging from 77% to 79%, indicating that the instructional materials are feasible and practical for classroom use. Further studies are recommended to examine effectiveness through experimental designs and to expand the development of interactive media.

How to Cite:

Muzdalipah, I., Hidayat, E., Rustiana, R., & Kurniasih, D. (2026). How Minimum Competency–Oriented Geometry Instruction Supports Students' Mathematical Literacy: Insights from A Design-Based Study. *Journal of Authentic Research on Mathematics Education, 8*(1), 116-131. https://doi.org/10.37058/jarme.v3i1.17868

1. INTRODUCTION

Since 2021, Ministry of Education, Culture, Research, and Technology has introduced new policies aimed at improving the quality of education, one of which is the replacement of the National Exam with the National Assessment. The National Assessment is designed to comprehensively capture the quality of learning processes and outcomes in primary and secondary education. Its main components consist of the Minimum Competency Assessment (MCA), the Character Survey, and the Environmental Survey (Cahyanovianty & Wahidin, 2021; Pusat Asesmen dan Pembelajaran Litbang Kemdikbud RI, 2020). The MCA specifically measures reading literacy and numeracy literacy, with an emphasis on reasoning and problem-solving rather than memorization (Novita et al., 2021; Rohim, 2021).

Mathematical literacy is an essential competency that students need in order to face the challenges of daily life. In international research and assessment frameworks, mathematical literacy is understood as the ability of individuals to meaningfully use mathematics in various real-world contexts through three main cognitive processes: formulating, employing, and interpreting. Specifically, the Programme for International Student Assessment (PISA) defines mathematical literacy as the capacity to formulate real-world problems into mathematical structures, apply mathematical concepts, procedures, facts, and tools to solve those problems, and interpret and evaluate the obtained results within real contexts so that the solutions are relevant, applicable, and logically sound in everyday life.

However, the results of PISA 2022 indicate that Indonesian students' mathematical literacy remains low. Indonesia's mathematics score was recorded at 366, significantly below the OECD average of 472 (OECD, 2023). The official PISA 2022 report also shows an unprecedented decline in mathematics performance, accompanied by an increase in the proportion of students classified as "low performers" (below the basic proficiency level). This means that many Indonesian students did not reach Level 2, which is considered the minimum level required to apply mathematics in real-world contexts (OECD, 2023). Such low performance suggests that students are still unable to apply mathematical concepts learned in the classroom to solve contextual problems (Nisa & Manoy, 2022; Samosir et al., 2024).

Mathematical literacy and numeracy literacy are interrelated competencies in mathematics education. Mathematical literacy encompasses the ability to formulate, apply, and interpret mathematics in various real-life contexts, whereas numeracy literacy focuses on the ability to use numbers, data, and mathematical representations to reason and make everyday decisions (OECD, 2023). Conceptually, numeracy literacy can be viewed as a component of mathematical literacy that serves as an essential foundation for developing reasoning skills and contextual problem-solving abilities.

Geometry is one of the content areas explicitly assessed in both the Minimum Competency Assessment (MCA) for numeracy and the Programme for International Student Assessment (PISA). Within the AKM framework, geometry is used to evaluate students' abilities to understand space, shape, and measurement, as well as to reason about contextual problems through visual representations (Pusat Asesmen dan Pembelajaran Litbang Kemdikbud RI, 2020). At the international level, PISA categorizes geometry under the Space and Shape domain, which emphasizes the ability to formulate, employ, and interpret mathematics in real-life contexts (OECD, 2023). However, numerous studies have reported that Indonesian students continue to experience substantial difficulties in geometry, particularly in constructing mathematical models, applying appropriate concepts, and interpreting solution outcomes(Angriani et al., 2022; Kiraam et al., 2025; Marsyandia et al., 2025). These findings underscore the need for geometry instruction that is explicitly oriented toward the development of mathematical literacy.

Instructional materials are systematically organized sets of learning resources designed to support the teaching and learning process (Prastowo, 2015 p. 28). One effective approach to addressing students' low mathematical literacy in geometry is the development of well-designed instructional materials. Learning materials play a crucial role in shaping meaningful learning experiences by guiding students to connect mathematical concepts with real-life contexts, supporting reasoning processes, and facilitating problem-solving beyond procedural calculations. Previous studies have shown that well-designed instructional materials can enhance students' engagement, conceptual understanding, and ability to solve contextual mathematical problems (Gebremeskel et al., 2025; Şentürk & Zeybek, 2019). In geometry learning, instructional materials that emphasize visual representations, contextual tasks, and reflective activities are particularly important, as these elements support students' ability to formulate, apply, and interpret mathematical ideas (Angriani et al., 2022; Marsyandia et al., 2025). Furthermore, research indicates that inadequate or poorly designed instructional materials may hinder instructional reform and limit opportunities for developing mathematical literacy (Fan et al., 2025). Therefore, the development of geometry instructional materials oriented toward mathematical literacy is considered a relevant and strategic solution to bridge the gap between assessment demands such as MCA and PISA and students' actual learning experiences in the classroom.

Studies published in the Journal of Authentic Research on Mathematics Education indicate that students continue to experience difficulties when solving MCA-based problems, particularly in aspects related to mathematical literacy and contextual reasoning (Haryati & Muhtadi, 2026; Vera Alif Hazira & Hidayah, 2023). In addition, the study of Putri et al., (2025) also highlight the importance of developing media and instructional materials as an effort to improve the quality of mathematics learning.

Although the National Assessment policy through MCA demands the development of applied mathematical literacy, and PISA identifies geometry as a key domain for assessing the ability to formulate–employ–interpret, a clear gap remains between the expectations of these assessments and actual geometry learning practices in classrooms. Previous studies have largely focused on evaluating student performance or on conceptual material development, without examining how geometry instruction aligned with minimum competency standards can directly support students' mathematical literacy. The novelty of this study lies in its effort to design and empirically test minimum competency–oriented geometry instruction through a design-based approach, thereby generating both empirical insights and instructional designs that are relevant to MCA policy and to the development of mathematical literacy within the geometry domain.

2. METHODS

This study employs a Research and Development (R&D) approach, which is a research method used to develop or validate products for educational and instructional purposes (Sugiyono, 2013 p. 4). Research findings obtained through this approach are utilized to design new educational products or procedures, which are then tested, evaluated, and systematically refined until they meet specific standards (Gall et al., 2003 hlm. 569). In this study, the R&D approach was used to produce and examine the effectiveness, practicality, and validity of an educational product, namely MCA-based instructional materials for geometry content. The development process follows the ADDIE model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009 p. 2), as illustrated in the following framework.

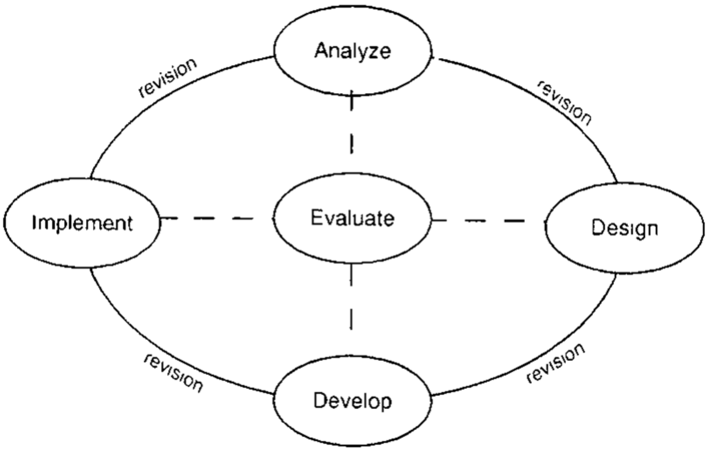


Figure 1. ADDIE Model Chart (Branch, 2009 p. 2)

In the Analysis stage, it is necessary to Identify the probable causes for a performance gap (Branch, 2009 p. 22)). The researcher conducted needs identification through interviews with subject teachers, analysis of mathematics learning performance, analysis of learners' characteristics, and analysis of relevant concepts (geometry) and learning objectives to be integrated into the MCA-based instructional materials. The analysis of mathematics learning performance aimed to determine the current implementation of mathematics instruction, including challenges and needs occurring in the classroom. The analysis of learner characteristics was conducted to understand the condition of students as product users. The content analysis included identifying concepts, facts, principles, and procedures within geometry that align with MCA and mathematical literacy. In addition, learning objective analysis was carried out to ensure alignment with MCA.

In the Design stage, instructional content and learning tools were designed with reference to learning outcomes and objectives. This stage also involved developing assessment instruments (including questionnaires on goal and content quality, technical quality, and instructional quality) and selecting competencies to be measured by the instructional materials. Subsequently, the instructional materials were compiled based on the initial design, validated by subject-matter experts and media experts, and prepared for field testing. The main purpose of this stage was to obtain a valid product prior to implementation. In the Implementation stage, the product deemed feasible by experts was tested on a small scale and then on a larger scale with junior high school students to examine instructional quality and the effectiveness of the instructional materials during classroom use. Finally, the Evaluation stage was conducted based on field test findings (questionnaires, feedback from validators, and students' responses) to revise and refine the AKM-based instructional materials for geometry content.

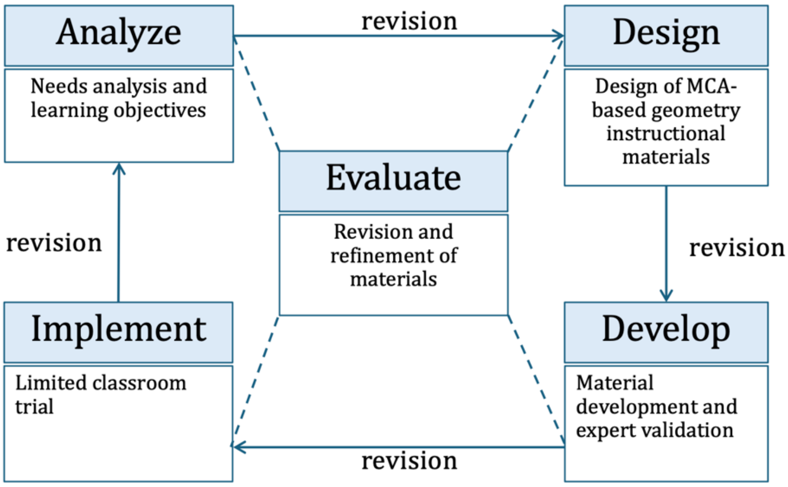


Figure 2. The Research Flow (ADDIE Model)

2.1. Research Subject

The research subjects were 25 eighth-grade students at SMP Negeri 1 Kota Banjar (July–November 2023), selected through purposive sampling as they met the aims of developing AKM-based geometry teaching materials at the junior secondary level (Cohen dkk., 2017 p. 218). The inclusion criteria were: active Grade VIII students currently studying geometry, participating in the implementation sessions, and willing to complete the response questionnaire with parental/guardian consent. This context was chosen considering typical student characteristics (varied ability levels, predominantly visual learning styles, and limited exposure to contextual problems), making it relevant for evaluating the practicality and feasibility of the product in an authentic instructional setting. The procedure complied with educational research ethics (school permission, informed consent, and data confidentiality) and focused on the use of the teaching materials in regular classroom settings without any high-risk interventions.

2.2. Data Collection

Data collection in this research was carried out using several complementary methods to obtain accurate information related to the development of MCA-based instructional materials on geometry content. The first technique was an unstructured interview (Phillips & Stawarski, 2008) conducted with a mathematics teacher as a preliminary study. This interview was open-ended and did not follow a rigid guideline, allowing the researcher to explore in-depth information regarding learners' characteristics, instructional media used, and school facilities. The purpose of the interview was to identify problems encountered in mathematics learning and to determine the need for developing MCA-based instructional materials.

The second technique was a rating-scale questionnaire (Phillips & Stawarski, 2008) used to assess the feasibility of the instructional materials developed in the study. The questionnaire instrument was distributed to two respondent groups: expert validators (content experts and media experts) and students. The questionnaire for experts aimed to assess content and objective quality, technical quality, and instructional quality of the materials. Meanwhile, the questionnaire for students was used to obtain their responses toward the developed instructional materials. The following table presents the feasibility criteria for instructional materials, adapted from Walker & Hess (1984 p. 206) and modified as necessary to suit the media being developed.

Table 1. Eligibility Criteria for Instructional Materials

Yes	Instructional quality	Content Quality and Purpose	Quality Engineering
1	Providing Learning Opportunities	Accuracy	Readability
2	Provide help to study	Importance	Easy to use
3	Motivating quality	Completeness	Display quality
4	Instructional flexibility	Balance	Quality of Reply Views
5	Social quality of Instructional interaction	Interests/attention	Quality of Program Management
6	Test Quality and Assessment	Suitability to the student's situation	Quality of Documentation
7	Can have an impact on students		

2.3. Data Analysis

Data analysis aimed to evaluate the feasibility and quality of the MCA-based instructional materials for geometry content from three main dimensions: content and objective quality, instructional quality, and technical quality as well as to identify improvement inputs derived from questionnaires, validator feedback, and student responses as the basis for product revision. The researcher employed both quantitative and qualitative data analysis. Quantitative analysis was carried out on the questionnaire results from students and experts (Cohen et al., 2017 hlm. 725), while qualitative analysis was applied to the interview data (Cohen et al., 2017 hlm. 643). The questionnaire scoring table used a 1–4 Likert scale. We used a 1–4 scale (even/forced-choice) to avoid neutral responses, which often function as escape or fence-sitting choices, and to produce clearer data for instructional material improvement decisions. Experimental evidence shows that neutral options can be used validly by some respondents but are also misused in other cases; therefore, removing the midpoint is acceptable for non-sensitive contexts such as content–instructional–technical evaluation. From a psychometric perspective, comparisons between 4- and 6-point formats indicate equivalent reliability and model fit, suggesting no strong statistical justification for switching from a 4-point scale when the instrument is already well-established. Other studies have also found that criterion validity does not depend on the number of response categories, a 4-point format can reduce method variance without sacrificing trait information in specific contexts (Chang, n.d.; Kankaraš & Capecchi, 2025; Santa et al., 2019). The product criteria as presented in Table 2 below:

Table 2. Product Criteria

Criteria	**Rating (%)**
Highly Valid	$80 < N \leq 100$
Valid	$60 < N \leq 80$
Quite Valid	$40 < N \leq 60$
Less Valid	$20 < N \leq 40$
Invalid	$0 < N \leq 20$

3. RESULTS AND DISCUSSION

This study aims to develop MCA-based geometry teaching materials to support junior secondary students' mathematical literacy, particularly in the formulate–employ–interpret processes. The research targets include: (1) producing AKM-based geometry instructional materials, (2) evaluating product feasibility through expert validation by content and media specialists, (3) examining the practicality of the materials based on students' responses, and (4) obtaining an initial overview of the materials' potential effectiveness in supporting mathematical literacy.

3.1. Results

Analysis

The analysis of mathematics learning performance based on interviews with the teacher indicated that: 1) the teacher used lecturing and worksheet-based exercises from workbooks and textbooks; 2) the main instructional media were the whiteboard and worksheets, with no use of visual or interactive media; 3) evaluations were conducted in written form using procedural questions, without incorporating literacy- or context-based questions; 4) approximately 70% of students were passive, with only 30% actively asking or answering questions; 5) 48% of students scored below the minimum competency criterion on geometry material based on daily test scores; and 6) the average numeracy literacy score from the MCA results was 412 (Basic category), indicating student difficulties with context-based problems.

Based on these findings, the instruction was teacher-centered, the media were not varied, and learning did not support mathematical literacy. Students therefore require instructional materials that are more visual, contextual, and problem-solving oriented.

The analysis of learner characteristics showed that: 1) students' interest in learning mathematics was low (61%), with students perceiving mathematics as difficult and boring; 2) students' learning styles consisted of 52% visual, 30% auditory, and 18% kinesthetic learners, indicating a dominant need for images/visuals; 3) students' mathematical literacy levels ranged from low to moderate, where students were able to perform calculations but struggled with contextual reasoning; and 4) independent learning readiness was 40%, with most students requiring teacher guidance. Based on this information, students need visualization, contextual examples, and guided problem-solving steps.

The analysis of geometry content included the identification of geometry concepts, facts, principles, and procedures relevant to MCA and mathematical literacy, as shown in Table 3.

Table 3. Material Concept Analysis

Components	Sample Material
Facts	Names of flat builds, build spaces, angles, point notation (A,B,C).
Concept	Area, circumference, volume, space building nets, angular relationships.
Principle	Width & volume formulas, triangle theorem, opposite/opposite angular relations.
Procedure	Calculate area, determine volume, read diagrams/buildings, understand context problems.

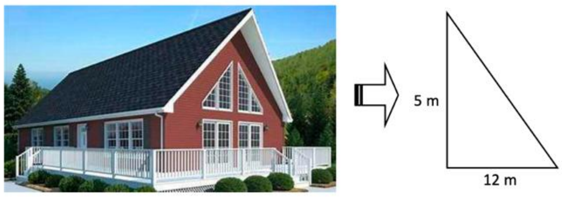
In MCA, geometry content aligns with the Space & Shape domain, emphasizing cognitive processes that include Formulate, Employ, and Interpret, and is presented in real-world contexts such as personal, societal, scientific, and occupational settings. The question types generally involve objects or real-life situations such as buildings, maps, bridges, or park designs, requiring students to perform geometric operations such as computing area, volume, transformations, or scale use. However, learning outcomes show that although students tend to be able to carry out procedural calculations, they often struggle to interpret contexts, such as reading maps or diagrams, and become confused when required to formulate problems into mathematical models. This indicates that mathematical literacy in geometry demands not only computational skills, but also contextual understanding, representational competency, and reasoning abilities.

Learning objectives were derived from the curriculum. Referring to the Kurikulum Merdeka, the learning objective is: “Students are able to identify, represent, and compute geometric quantities in real-world problems.” This general objective is further specified into the following indicators: 1) identifying two- and three-dimensional shapes in everyday life situations (Formulate process); 2) extracting and using geometric information (length, area, volume) to solve contextual problems (Employ process); 3) interpreting the results of area and volume calculations to provide solutions in real-world contexts (Interpret process); 4) using visual representations such as maps, diagrams, or nets to understand the shape and dimensions of objects; and 5) explaining solution steps coherently based on geometric concepts.

Design

In this stage, the researcher designed the instructional content and learning tools with reference to the learning outcomes and objectives obtained during the Analysis stage. The content design focused on geometry materials (area, perimeter, volume, and nets of solids). The structure of the instructional materials included: 1) contextual introduction (e.g., school maps, city parks); 2) core content (area & volume formulas, visual examples); 3) AKM-based exercises (contextual HOTS items); 4) reflection section (looking back) for result interpretation; and 5) media elements: visual illustrations, tables, and nets to support students' visual learning styles.

Perhatikan permasalahan berikut



Jendela rumah Alya dibuat mengikuti bentuk dari atap rumah. Seperti pada di gambar bahwa jendela dibuat menjadi dua bagian segitiga dengan ukuran yang sama. Diketahui bahwa panjang sisi atap 1:2 dengan sisi miring jendela.

Di antara berikut ini, pilihlah pernyataan yang benar!

- ☐ Panjang sisi atap rumah Alya adalah 26 m
- ☐ Luas jendela rumah Alya adalah 45 m^2
- ☐ Jika panjang rumah Alya adalah 180 m maka luas atap rumah Alya adalah 9360 m^3
- ☐ Jika diketahui bahwa tinggi atap rumah Alya adalah 10 m maka lebar rumah Alya adalah 25 m

Figure 3. Contextual HOTS Item

The researcher developed validation questionnaires for content experts and media experts to assess three aspects: instructional quality (7 indicators), content and objective quality (6 indicators), and technical quality (6 indicators), referring to the criteria in Table 1. A student questionnaire was also developed to capture learner perspectives. The student questionnaire was designed to gather feedback on three main aspects: instructional quality (4 indicators), content and objective quality (3 indicators), and technical quality (3 indicators). The following are the indicator details for the student questionnaire:

Table 4. Student Questionnaire Indicators

No	Instructional quality	Content and objective Quality	Technical Quality
1	Teaching materials provide ample learning opportunities.	The material in the teaching materials is in accordance with the basic competencies and learning objectives.	The language used is easy to understand.
2	The teaching materials helped me understand the steps to solve the questions.	The material presented is important and relevant to daily life.	Teaching materials are easy to use both in the classroom and independent study.
3	The teaching materials made me more motivated to learn mathematics.	The material is presented completely and systematically.	The display of teaching materials is attractive and clear.
4	Flexible teaching materials are used in various activities (discussions, group work).	The material is balanced between concepts, examples, and exercises.	Watching the answers makes it easier for me to check and reflect on the results.
5	The teaching materials made it easier for me to discuss with friends.	The material was interesting and able to hold my attention.	The flow of activities in the teaching materials is well structured.
6	Teaching materials are complemented by appropriate exercises and assessments.	The material is in accordance with my situation and characteristics as a student.	The format and layout of the teaching materials are neat and according to the standards.

No	Instructional quality	Content and objective Quality	Technical Quality
7	The teaching materials had a positive impact on my understanding.		

Development

At this stage, the draft of the AKM-based instructional materials (geometry content: area, perimeter, volume, and nets) designed in the Design phase was fully developed and subsequently validated by content experts and media experts in order to obtain a valid product before implementation. The following are the validation results from the content expert and media expert:

Table 5. Validation Results by Experts

Aspects	Validator	Max Score	Score	Percentage	Categories
Content Quality & Purpose	Material Expert	24 (6×4)	19	79,0%	Valid
	Media Member	24 (6×4)	17	70,8%	Valid
Instructional Quality	Material Expert	28 (7×4)	21	75,0%	Valid
	Media Member	28 (7×4)	20	71,4%	Valid
Technical Quality	Material Expert	24 (6×4)	18	75,0%	Valid
	Media Member	24 (6×4)	18	75,0%	Valid
Quantity	Material Expert	76	58	76,3%	Valid
	Media Member	76	55	72,4%	Valid
Combined Average				74,3%	Valid

The content and objectives of the instructional materials were judged to be appropriate and relevant to the learning outcomes, achieving a percentage above 70%. However, it was recommended to enrich contextual examples to maintain students' interest. In terms of instructional aspects, the materials were considered capable of providing learning opportunities and support with a score of approximately 75%, although improvements were needed regarding the clarity of assessment rubrics, particularly in AKM-based exercises. Technically, the visual layout and usability received strong ratings (around 75–77%), yet it was suggested to refine the wording and clarify answer displays so that students can better engage in reflection. All aspects were aligned with the dimensions and indicators used in the validation instrument.

Implementation

After the materials were revised based on feedback from the content and media experts, they were tested on 25 seventh-grade students at SMP Negeri 1 Kota Banjar. The results of the student questionnaire are presented in Table 6:

Table 6. Student Questionnaire Results

Aspects	Max Score	Score	Percentage	Categories
Content Quality & Purpose	700 (6×4×25)	545	77,9%	Valid
Instructional Quality	600 (7×4×25)	465	77,5%	Valid
Technical Quality	600 (7×4×25)	473	78,8%	Valid
Quantity	1900	1483	78,1%	Valid

The three validation aspects of the instructional materials fell within the Valid category (≥60% and <80%), indicating that the materials were deemed suitable for use from the students' perspective. The distribution analysis showed a strong tendency toward scores of 3–4, indicating that the materials possess instructional effectiveness, relevant content and objectives, and user-friendly technical aspects. Minor inputs represented by score 2 indicated the need to improve the balance between examples and exercises within the content aspect and to enhance answer displays to support reflection within the technical aspect before wider dissemination. These findings support the conclusion that the instructional materials meet feasibility standards with several improvement suggestions for optimization.

Evaluation

Based on the implementation results, the MCA-based instructional materials were feasible for use with minor revisions prior to broader dissemination. Recommended improvements included refining the wording for better readability, adding answer displays to support reflection, and balancing the proportion of contextual examples and HOTS exercises.

3.2. Discussion

The analysis stage showed that mathematics instruction remained teacher-centered, with instructional media limited to the whiteboard and worksheet-based materials, and evaluation still dominated by procedural questions. This condition reduced students' opportunities to practice reasoning and problem solving, resulting in suboptimal development of mathematical literacy. This aligns with the findings of Nisa & Manoy (2022), who argue that mathematical literacy requires exposure to contextual tasks rather than merely procedural exercises, and that instruction focused on memorization leads students to fail in interpreting real-world tasks. Findings by Kappassova et al., (2025) further indicate that procedural teaching hinders students' ability to think rationally and solve problems, keeping their mathematical literacy low. Thanheiser & Melhuish (2023) emphasize the need for student-centered approaches through dialogue and discussion so that students learn to reason rather than simply pursue correct answers. Additionally, the data showed that 70% of students were passive, 48% scored below the minimum mastery criterion, and MCA numeracy results fell within the Basic category reinforcing the existence of a learning gap between MCA demands and current instructional practice. This explains why students were able to perform computations but struggled when problems were presented in contextual form because they had insufficient practice with the formulate–employ–interpret processes emphasized in the PISA framework.

The learner analysis revealed that visual learning styles were dominant (52%), interest in learning mathematics was low (61%), and mathematical literacy levels were in the low-to-medium category. This information had direct design implications: students require support in the form of visualization, step-by-step solution guidance, and contexts that are close to real life. This aligns with findings by Şentürk & Zeybek (2019), who assert that instructional materials with visual and contextual content enhance engagement and conceptual understanding. Marikyan, (2023) also found that the use of visuals (images, diagrams, manipulatives) in mathematics instruction enhances analytical thinking, engagement, and motivation. These findings are reinforced by Sylviani et al., (2024), whose study showed that integrating visual arts (images, illustrations) into mathematics instruction significantly increases students' interest and motivation in learning mathematics.

The analysis of geometry content showed that MCA geometry aligns with the Space & Shape domain, is embedded in real-world contexts, and requires operations such as area, volume, nets, and scale. This is consistent with the OECD (2023) report indicating that the Space & Shape domain demands the ability to formulate spatial information, apply geometric concepts, and interpret results in context. The fact that students were "able to compute but struggled to interpret context" is a manifestation of failure in the interpretation stage, which PISA regards as the highest dimension of mathematical literacy. Newman's analysis of students' errors on PISA Space & Shape items showed that many students struggled at the stages of understanding, transforming the problem, and executing solutions particularly in interpreting and processing information from real contexts (Kiraam dkk., (2025). Even at the upper secondary level, many students still failed to interpret results within real-world contexts (Marsyandia et al., 2025). These findings indicate that literacy within the Space & Shape domain remains suboptimal.

During the design and development stages, instructional materials were constructed to address these analytic needs by incorporating visual, contextual, and formulate–employ–interpret features. This was reflected in the structure of the materials, which included contextual introductions, core content, MCA-based exercises, reflection components, and visualizations of nets. This design choice was not merely technical, but directly addressed the question of "why students struggle with mathematical literacy" namely because PISA/MCA demands contextual reasoning rather than purely procedural manipulation. The inclusion of instructional, content-objective, and technical dimensions in the validation instrument also aligned with the Walker & Hess (1984 p. 206) quality model, which emphasizes learning opportunity, instructional support, and visual/technical quality.

Expert validation results showed that all aspects were within the valid category (≥70%), with an average score of 74.3%. Theoretically, this indicates that the product achieved content validity, instructional validity, and technical validity consistent with Gall et al. (2003 p. 569) in educational R&D. Expert suggestions related to contextual enrichment, rubric clarity, and visual adjustments indicated the need for refinement to ensure that the materials are not only valid but also effective. These findings align with Fan dkk., (2025) who found that insufficient material support within instructional resources can limit learning opportunities.

At the implementation stage, trials with students showed that the three evaluation aspects content & objectives, instructional, and technical were all within the Valid category

(77–79%). These data provide empirical evidence that the materials are not only theoretically feasible (based on expert validation) but also practically feasible from the users' perspective. For example, the high score on the technical aspect (78.8%) indicated that the visual format and readability suited students' predominantly visual learning styles, reinforcing the design rationale. Meanwhile, minor scores related to answer display indicated students' need for scaffolding, as mathematical literacy requires reflection and verification processes rather than merely final answers. This is consistent with Cuong et al., (2025), who emphasize that effective instructional materials do not only convey concepts but also provide support for problem solving.

Overall, the data and analysis in this study address the research objective, namely to develop AKM-based instructional materials in geometry that are valid and feasible for improving students' mathematical literacy. The low mathematical literacy identified in the analysis phase, theoretical validity in the expert phase, and positive acceptance in the implementation phase demonstrate that the proposed solution is on a sound trajectory. This is theoretically reinforced by Branch (2009), who states that effective instructional design aligns initial needs, product design, and implementation. Thus, the discussion demonstrates coherence between need → design → validity → feasibility, not merely as procedural steps, but as a logical explanation of why these data emerged and how theoretical perspectives explain the observed findings.

4. CONCLUSION

This study successfully developed teaching materials based on the Minimum Competency Assessment (MCA) for geometry topics using the ADDIE development model. Validation results from subject-matter experts and media experts indicated that all aspects content and objective quality, instructional quality, and technical quality were categorized as valid, with an average percentage of 74.3%, indicating that the product is suitable for use. The trial implementation with students strengthened these findings, showing validity scores ranging from 77% to 79% across the three aspects. These results indicate that the developed teaching materials meet both theoretical and practical standards for classroom implementation.

Despite these positive outcomes, feedback from validators and student responses suggested the need for minor improvements, such as the addition of contextual examples, clearer assessment rubrics, and enhanced visual appearance to make the teaching materials more engaging and effective. Overall, the development of AKM-based teaching materials provides a relevant solution for improving students' mathematical literacy, particularly in the formulate–employ–interpret process in accordance with the PISA framework. This study recommends further development by expanding contextual problem situations, enriching interactive media, and conducting wider-scale dissemination.

ACKNOWLEDGMENTS

The author expresses gratitude to all parties who supported the implementation of this research. Appreciation is extended to Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) Universitas Siliwangi for the facilities and opportunities provided, as well as to the teachers and students of SMP Negeri 1 Kota Banjar who participated in the trial of the teaching materials. We also acknowledge the material and media expert validators who dedicated their time to provide valuable input regarding content, instructional, and technical validity. Our thanks are also conveyed to colleagues and all individuals who assisted in data collection, analysis, and the refinement of this manuscript. May the contributions of all parties bring benefit to the development of mathematics education.

REFERENCES

Angriani, A. D., Ruslan, & Tampa, A. (2022). Students' difficulties in solving geometric literacy problems. *ICSAT INTERNATIONAL PROCEEDING*, *11*(2), 219–227. https://ojs.unm.ac.id/icsat/article/view/39068

Branch, R. M. (2009). Instructional Design: The ADDIE approach. in *instructional design: the ADDIE approach*. Springer US. https://doi.org/10.1007/978-0-387-09506-6

Cahyanovianty, A. D., & Wahidin. (2021). Analisis kemampan numerasi peserta didik kelas viii dalam menyelesaikan soal asesmen kompetensi minimum. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *05*(02), 1439–1448. https://doi.org/10.31004/cendekia.v5i2.651

Chang, L. (n.d.). *A psychometric evaluation of 4-point and 6-point likert-type scales in relation to reliability and validity*.

Cohen, L., Manion, L., & Morrison, K. (2017). Research methods in education. in *syria studies* (Vol. 7, Number 1). Routledge. https://doi.org/10.4324/9781315456539

Cuong, L. M., Tien-Trung, N., Ngu, P. N. H., Vangchia, V., Thao, N. P., & Thao, T. T. P. (2025). Mathematics problem-solving research in high school education: Trends and insights from the Scopus database (1983–2023). *European Journal of Science and Mathematics Education*, *13*(2), 77–89. https://doi.org/10.30935/scimath/16038

Fan, L., Qi, C., Seah, W. T., & Liu, Q. (2025). Research on mathematics textbooks in relation to curriculum development and instructional reform: recent advances and future directions. *ZDM - Mathematics Education*, *57*(5), 845–857. https://doi.org/10.1007/s11858-025-01736-6

Gall, M. D., Gall, J. P., & Walter R. Borg. (2003). *Educational research- an introduction* (7th Edition). Pearson Education Inc.

Gebremeskel, A. A., Ayele, M. A., & Wondimuneh, T. E. (2025). Student engagement, conceptual-understanding, and problem-solving ability in learning plane geometry through an integrated instructional approach. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(5). https://doi.org/10.29333/ejmste/16391

Haryati, H., & Muhtadi, D. (2026). Exploring students' conceptual and procedural errors in akm-based central tendency tasks. *Journal of Authentic Research on Mathematics Education*, *8*(1). https://doi.org/10.37058/jarme.v3i1.15924

Kankaraš, M., & Capecchi, S. (2025). Neither agree nor disagree: use and misuse of the neutral response category in Likert-type scales. *Metron*, *83*(1), 111–140. https://doi.org/10.1007/s40300-024-00276-5

Kappassova, S., Abylkassymova, A., Bulut, U., Zykrina, S., Zhumagulova, Z., & Balta, N. (2025). Mathematical literacy and its influencing factors: A decade of research findings (2015-2024). In *Eurasia Journal of Mathematics, Science and Technology Education* (Vol. 21, Number 7). Modestum LTD. https://doi.org/10.29333/ejmste/16615

Kiraam, R., Sapta Nusantara, D., & Tiona Pasaribu, F. (2025). *Students' errors in solving pisa questions on space and shape content*. *12*(2), 149–162. https://ejournal.bbg.ac.id/numeracy

Marikyan, G. (2023). Teaching mathematics with visuals gohar marikyan. *Athens Journal of Sciences*, *10*(4), 231–240. https://doi.org/10.30958/ajs.10-4-3

Marsyandia, I. P., Nusantara, D. S., & Gustiningsi, T. (2025). Assessing students' mathematical literacy through pisa items in the space and shape content. *Brillo Journal*, *5*(1), 1–14. https://doi.org/10.56773/bj.v5i1.153

Nisa, S. B., & Manoy, J. T. (2022). Profil pemecahan masalah matematika kontekstual siswa ditinjau dari kemampuan matematika. *Jurnal Ilmiah Pendidikan Matematika*, *11*(1).

Novita, N., Mellyzar, M., & Herizal, H. (2021). Asesmen Nasional (AN): pengetahuan dan persepsi calon guru. *JISIP (Jurnal Ilmu Sosial Dan Pendidikan)*, *5*(1). https://doi.org/10.58258/jisip.v5i1.1568

OECD. (2023). PISA 2022 Results (Volume I). In *Pisa 2022: I*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Phillips, P. P., & Stawarski, C. A. (2008). *Data collection: planning for and collecting all types of data* (P. P. Phillips & J. J. Phillips, Eds.). pfeiffer.

Prastowo, A. (2015). *Panduan kreatif membuat bahan ajar inovatif*. Diva Press.

Pusat Asesmen dan Pembelajaran Litbang Kemdikbud RI. (2020). *AKM dan implikasinya pada pembelajaran*. Pusat Asesmen Dan Pembelajaran Badan Penelitian Dan Pengembangan Dan Perbukuan Kemdikbud RI. https://hasilun.puspendik.kemdikbud.go.id/akm/file_akm2_202101_1.pdf

Rohim, D. C. (2021). Konsep asesmen kompetensi minimum untuk meningkatkan kemampuan literasi numerasi siswa sekolah dasar. *Jurnal VARIDIKA*, *33*(1), 54–62. https://doi.org/10.23917/varidika.v33i1.14993

Samosir, C. M., Herman, T., Prabawanto, S., Melani, R., & Mefiana, S. A. (2024). Students' difficulty in understanding problems in the contextual problem-solving process. *PRISMA*, *13*(1), 20. https://doi.org/10.35194/jp.v13i1.3726

Santa, U. C., Covitality, B. P., Wolf, M. G., Nylund-Gibson, K., Dowdy, E., & Furlong, M. (2019). *An analytic approach for deciding between 4-and 6-point likert-type response options*. www.project-covitality.info

Şentürk, C., & Zeybek, G. (2019). Teaching-learning conceptions and pedagogical competence perceptions of teachers: a correlational research. *Research in Pedagogy*, *9*(1), 65–80. https://doi.org/10.17810/2015.92

Sugiyono. (2013). *Metode penelitian kuantitatif, kualitatif, dan R& D*. Alfabeta.

Sylviani, S., Permana, F. C., & Azizan, A. T. (2024). Enhancing mathematical interest through visual arts integration: a systematic literature review. *International Journal of Education in Mathematics, Science and Technology*, *12*(5), 1217–1235. https://doi.org/10.46328/ijemst.4118

Thanheiser, E., & Melhuish, K. (2023). Teaching routines and student-centered mathematics instruction: The essential role of conferring to understand student thinking and reasoning. *Journal of Mathematical Behavior*, *70*. https://doi.org/10.1016/j.jmathb.2023.101032

Vera Alif Hazira, K., & Hidayah, I. (2023). Analisis literasi matematis siswa pada soal berbasis asesmen kompetensi minimum. *Journal of Authentic Research on Mathematics Education*, *5*(2). https://doi.org/10.37058/jarme.v5i2.5895

Walker, D. F., & Hess, Robert. D. (1984). *Instructional Software : Principles and perspectives for design and use*. Wadsworth Pub. Co.