

Development of Barinjam Learning Media for Algebraic Expression Operations at SMP Negeri 1 Permata Kecubung

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Abstrak

Algebra is a fundamental topic in junior secondary mathematics, yet many Grade VII students experience difficulty because algebraic operations require a transition from concrete arithmetic thinking to abstract symbolic reasoning. This study aimed to develop and validate BARINJAM, or Board Algebra Operations Joyful Activity in Mathematics, as a concrete, low-cost, offline, and culturally contextualized learning medium for algebraic operations at SMP Negeri 1 Permata Kecubung. The study employed a research and development design using the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation. The participants were 33 Grade VII students from classes VII A and VII B, one mathematics teacher, and three expert validators in material, media, and language. Data were collected through expert validation sheets, teacher and student response questionnaires, observation, and documentation. The data were analyzed descriptively by converting validation and response scores into percentages. The results showed that BARINJAM met the feasibility criteria, with material expert validation reaching 100%, media expert validation reaching 80.38%, and language expert validation reaching 100%. The small-scale trial showed a teacher response of 94.73% and a student response of 88%, while the large-scale trial after revision showed an increased teacher response of 98.68% and a student response of 89.24%. These findings indicate that BARINJAM is feasible and practical for supporting Grade VII algebra learning. The media helps represent variables, constants, positive and negative terms, and algebraic operations through concrete manipulation. Further research is needed to examine its effectiveness using complete pretest-posttest data, gain analysis, and statistical testing.

Keywords: BARINJAM, algebraic operations, learning media, mathematics education, concrete representation

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INTRODUCTION

Mathematics is a fundamental discipline that plays an essential role in daily life, scientific development, and technological progress. Its importance is reflected not only in students' ability to perform numerical calculations, but also in their capacity to reason logically, think critically, recognize patterns, represent relationships, and solve problems in meaningful contexts (Arfika Riestyan Rachmantika & Wardono, 2019). Mathematical competence therefore needs to be understood as a combination of procedural fluency and conceptual understanding, particularly when students are introduced to topics that require abstract reasoning. One of the most important topics in junior secondary mathematics is algebra, because it introduces students to variables, symbols, generalization, equivalence, and structural relationships. For Grade VII students, algebra represents a critical transition from arithmetic thinking, which is usually concrete and computational, toward symbolic reasoning, which requires students to interpret letters and operations as representations of mathematical relationships (Fardian et al., 2024; Kieran et al., 2016; Žakelj et al., 2024; Sun et al., 2023).

This transition is not only a matter of curriculum sequence, but also a cognitive challenge. Students in Grade VII, generally aged between 11 and 13 years, are still

strongly influenced by concrete reasoning when learning abstract concepts. Piaget's theory explains that learners gradually move from concrete operational thinking toward formal operational reasoning, meaning that abstract mathematical symbols should be connected to observable and manipulable representations (Khadijah, 2016). In algebra learning, this connection is especially important because students must understand that variables, coefficients, constants, equal signs, and operations are not isolated marks, but symbols that express quantities and relationships. Without adequate instructional support, students may memorize procedures without understanding the meaning behind algebraic manipulation. Recent studies also emphasize that algebraic thinking develops through mediation between concrete experiences, pictorial models, and abstract symbols (Ng, 2022; Booth & Koedinger, 2011). Therefore, algebra instruction requires learning environments that help students move gradually from physical representation to formal notation.

The need for such support was found in the learning conditions at SMP Negeri 1 Permata Kecubung. The school's 2024 education report showed that students' numeracy achievement had improved, with 77.5% of students reaching minimum competency compared with 42.22% in 2023. However, achievement in the algebra domain remained relatively low, with an average score of 58.56 in students' ability to use concepts, procedures, facts, and mathematical tools to solve daily problems involving algebra. Classroom observation also indicated that students experienced difficulty understanding algebraic operations because the material was perceived as abstract and was mostly delivered through textbook-based explanation and teacher demonstration. Learning activities tended to be teacher-centered, while students were more often involved in listening and note-taking than in manipulating, discussing, or constructing algebraic ideas. This condition suggests that the main problem was not limited to students' achievement, but also involved the limited availability of concrete and engaging media to support algebraic representation.

This problem shows a gap between the expected role of mathematics learning and the reality of classroom practice. Ideally, mathematics learning should develop students' rational, creative, and independent thinking because mathematical concepts are interconnected and can train students to understand patterns, relationships, and logical structures (Marni & Pasaribu, 2021). However, when algebra is introduced mainly as a set of symbolic procedures, students often fail to connect notation with conceptual meaning. Previous studies show that students frequently misunderstand the equal sign, treat letters as labels rather than variables, and rely on procedural manipulation without understanding the underlying structure (Ardiansari et al., 2020; Ardiansari et al., 2022; Welder, 2012; Ndemo & Ndemo, 2018). These findings indicate that students need instructional media that can transform algebraic expressions into visible, concrete, and manipulable forms before they are expected to operate with formal symbols.

Previous literature supports the use of concrete, pictorial, and abstract approaches to help students develop algebraic understanding. The concrete-pictorial-abstract approach provides a gradual pathway from physical manipulation to visual representation and finally to symbolic reasoning. Model-based strategies also help students visualize mathematical relationships before working formally with notation (Ng, 2022). Manipulatives, visual models, and interactive learning environments can reduce cognitive load and strengthen conceptual understanding because they allow learners to test, compare, and reorganize mathematical relationships (Booth & Koedinger, 2011; Birgin & Demirören, 2025). In the context of algebraic operations, such media can help students distinguish positive and negative terms, variables and constants, similar and dissimilar terms, and the structural meaning of addition, subtraction, multiplication, and division. This view is consistent with the idea that learning media can

make classroom interaction more active, efficient, and motivating when they are aligned with students' characteristics and learning needs (Arsyad, 2017).

Several specific media and instructional designs have been developed to support algebra learning, including algebra tiles, balance models, game-based activities, GeoGebra-supported learning, and interactive digital environments. These media provide students with opportunities to manipulate representations of variables, constants, positive and negative terms, and algebraic operations (Younes et al., 2020; Trgalová et al., 2009). Cognitive-load-aware instructional designs, such as structured worked examples, have also been reported to support algebraic problem solving by guiding novice learners through analysis, explanation, investigation, and application (Özcan, 2024). Nevertheless, many algebra learning media are digital, application-based, or dependent on devices and internet access. In many school contexts, especially classrooms with limited technological resources, teachers still need learning media that are simple, affordable, offline, durable, and easy to use during face-to-face instruction.

Another issue that requires attention is the limited integration of local cultural context in algebra learning media. Literature on contextual and culturally responsive mathematics learning suggests that materials connected to students' local experiences and identities can increase participation, ownership, and motivation in the classroom (Ardiansari et al., 2020; Ardiansari et al., 2022; Gueudet et al., 2017). However, cultural context should not merely function as decoration. It needs to be integrated in a way that supports students' emotional connection with the media while maintaining the accuracy of mathematical representation. This creates an opportunity to design algebra media that are not only concrete and practical, but also meaningful for students' local learning environment.

Based on this gap, the present study developed BARINJAM, or Board Algebra Operations Joyful Activity in Mathematics, as a concrete manipulative medium for Grade VII algebraic operations. BARINJAM was inspired by concrete algebra representations and by the local slogan of Sukamara Regency, "Gawi Barinjam," which means working together to achieve noble goals. The novelty of this study lies in the development of a low-cost, offline, board-based algebra medium that combines concrete manipulation, joyful learning activity, and local cultural identity. Unlike digital algebra media that require technological infrastructure, BARINJAM is designed to be directly used in classroom activities by representing variables, constants, positive and negative terms, and algebraic operations through physical objects and visual arrangements.

Accordingly, this study aims to develop and validate BARINJAM media for teaching algebraic operations to Grade VII students at SMP Negeri 1 Permata Kecubung. The study specifically focuses on producing a concrete, low-cost, offline, and culturally contextualized learning medium that can support students in representing variables, constants, positive and negative terms, and algebraic operations through direct manipulation. Through this development, BARINJAM is expected to serve as an instructional bridge between students' concrete reasoning and formal algebraic notation, making algebraic operations more accessible, engaging, and meaningful for Grade VII mathematics learning.

METHODOLOGY

This study employed a research and development design to produce and validate BARINJAM, or Board Algebra Operations Joyful Activity in Mathematics, as a learning medium for algebraic operations in Grade VII mathematics learning. Research and development was selected because the study aimed not only to identify a learning problem, but also to design, validate, revise, and evaluate an educational product based on expert judgment and user responses. This approach is consistent with Sugiyono (2017), who states that development research is used to

produce a specific product and examine its feasibility for use, and Sukmadinata (2015), who explains that development research aims to create new products or improve existing ones.

The development process followed the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was considered appropriate because it provides a systematic framework for connecting needs analysis, product design, prototype development, classroom implementation, and evaluation. In this study, the evaluation focused mainly on the feasibility and practicality of BARINJAM. Feasibility was examined through expert validation, while practicality was examined through teacher and student responses during product trials.

Research Setting and Participants

The study was conducted at SMP Negeri 1 Permata Kecubung, located on Jalan Tjilik Riwut No. 197, Ajang Village, Permata Kecubung District, Sukamara Regency, Central Kalimantan. The participants were Grade VII students in the 2025/2026 academic year, consisting of 17 students from class VII A and 16 students from class VII B, with a total of 33 students. The study also involved one mathematics teacher and three expert validators. The validators consisted of a material expert, a media expert, and a language expert. The material expert assessed the accuracy and suitability of algebraic content, the media expert assessed the visual design and usability of the product, and the language expert assessed the clarity and appropriateness of the language used in the media and supporting materials.

Development Procedure

The development of BARINJAM was carried out through five ADDIE stages. In the analysis stage, the researcher examined curriculum requirements, student characteristics, learning problems, and media needs. Curriculum analysis focused on learning outcomes, learning objectives, and indicators related to algebraic operations in Grade VII. Student and needs analyses were conducted through classroom observation, teacher information, and student learning conditions. The analysis showed that students perceived algebra as abstract and had difficulty connecting algebraic concepts with procedures, especially in addition, subtraction, multiplication, and division of algebraic expressions.

In the design stage, the researcher prepared the structure, layout, symbols, visual appearance, and operating procedures of BARINJAM. The media was designed as a board-based manipulative tool that represents variables, constants, positive terms, negative terms, and algebraic operations through concrete symbols. Supporting learning activities and worksheets were also prepared to guide students in using the media. Local cultural elements from Sukamara Regency and Central Kalimantan were integrated into the design to make the media more contextual and familiar to students.

In the development stage, the initial prototype was produced using simple and accessible materials. The prototype was then validated by material, media, and language experts. The validation process was used to obtain judgments, comments, and suggestions regarding content accuracy, media quality, symbolic clarity, visual consistency, usability, and language suitability. The product was revised based on the validators' feedback before being tested in classroom trials.

In the implementation stage, BARINJAM was tested through two trial phases. The small-scale trial involved one mathematics teacher and 10 Grade VII students selected from classes VII A and VII B. This trial aimed to examine the initial practicality of the media, including clarity of instructions, attractiveness, ease of use, and suitability for classroom learning. After revision, a large-scale trial was conducted involving all 33 Grade VII students. This trial was used to examine the practicality of the revised product in a broader classroom setting. In the evaluation stage, the researcher analyzed validation results, teacher responses, student responses, observation notes, and documentation to determine the feasibility and practicality of the final product.

Instruments and Data Collection

Data were collected using expert validation sheets, teacher response questionnaires, student response questionnaires, observation, and documentation. The material validation sheet assessed the suitability of content with learning objectives, conceptual accuracy, material relevance, material depth, contextuality, and presentation. The media validation sheet assessed visual design, layout, color composition, symbolic clarity, ease of use, durability, and suitability

for student characteristics. The language validation sheet assessed clarity, readability, sentence effectiveness, appropriateness for Grade VII students, and conformity with language standards. Teacher and student response questionnaires were used to collect practicality data. The teacher questionnaire measured perceptions of media design, ease of use, clarity of instructions, suitability of material presentation, and usefulness of the media in supporting algebraic operations learning. The student questionnaire measured attractiveness, clarity, ease of use, and usefulness of BARINJAM in learning algebraic operations. Observation and documentation were used to record the implementation process, product use, validation results, and revisions. Before data collection, the researcher obtained permission from the school and coordinated with the mathematics teacher. Student responses were reported in aggregate form without presenting individual identities.

Data Analysis

The data were analyzed using descriptive quantitative procedures. Scores from expert validation sheets and teacher-student questionnaires were converted into percentages by dividing the obtained score by the maximum score and multiplying by 100%. The percentage results from expert validation were interpreted using feasibility criteria adapted from Damayanti et al. (2018), while teacher and student responses were interpreted using practicality criteria. BARINJAM was considered feasible when expert validation results reached at least 80% and practical when teacher and student responses reached at least 70% with positive interpretation. Since this study focused on product feasibility and practicality, claims about learning effectiveness were not emphasized unless supported by complete learning outcome data, statistical test results, and learning gain analysis.

RESULTS AND DISCUSSION

Needs Analysis and Learning Problems

The development of BARINJAM media was initiated through a needs analysis conducted at SMP Negeri 1 Permata Kecubung, particularly in Grade VII mathematics learning on algebraic operations. The preliminary findings showed that students' general numeracy performance had improved based on the 2024 education report. In 2024, 77.5% of students reached minimum competency, increasing from 42.22% in 2023. However, the algebra domain remained a concern because students' average achievement in applying concepts, procedures, facts, and mathematical tools to solve daily problems involving algebra was only 58.56. This finding indicates that improvement in general numeracy was not fully accompanied by adequate development of algebraic reasoning.

Classroom observation further showed that students perceived algebraic operations as abstract and difficult. Many students had difficulty connecting algebraic concepts with procedures, especially in addition, subtraction, multiplication, and division of algebraic expressions. Learning activities were still dominated by teacher explanation, textbook use, and note-taking. As a result, students tended to be passive and showed limited engagement during mathematics lessons. The initial problem was therefore not only related to low algebra achievement, but also to the lack of concrete learning media that could help students represent algebraic ideas visually and manipulatively.

Table 1. Results of Needs Analysis in Algebra Learning

Aspect		Findings
General achievement	numeracy	77.5% of students achieved minimum competency in 2024
Previous achievement	numeracy	42.22% of students achieved minimum competency in 2023
Algebra achievement		The average score of algebra competency was 58.56
Student perception		Algebra was considered abstract and difficult

Aspect	Findings
Learning process	Learning was dominated by teacher explanation and note-taking
Student engagement	Students tended to be passive and less motivated
Interest in mathematics	Only around 50% of students expressed interest in mathematics

These findings became the basis for developing a concrete manipulative medium for algebraic operations. Grade VII students are in a transitional stage from arithmetic thinking to algebraic reasoning, so they need instructional support that connects concrete representations with formal mathematical symbols (Fardian et al., 2024; Kieran et al., 2016; Žakelj et al., 2024; Sun et al., 2023). BARINJAM was developed to respond to this need by representing variables, constants, positive and negative terms, and algebraic operations in a visible and manipulable form.

Design and Development of BARINJAM Media

The product developed in this study was BARINJAM, which stands for Board Algebra Operations Joyful Activity in Mathematics. BARINJAM was designed as a board-based manipulative medium for learning algebraic operations in Grade VII. The initial prototype used simple cardboard materials so that the media could be produced at low cost and used easily in classroom activities. The main purpose of the prototype was to help students understand algebraic forms concretely before moving to formal symbolic operations.

The initial design used shapes, colors, and symbols to represent algebraic components. The revised terminology used in this study refers to positive variable terms, negative variable terms, positive constants, negative constants, positive quadratic terms, and negative quadratic terms. This revision is important because the term “variable terms” is mathematically more accurate than “positive variables” or “negative variables.” Through these representations, students were expected to recognize that algebraic notation can be represented by concrete objects before being manipulated in symbolic form.

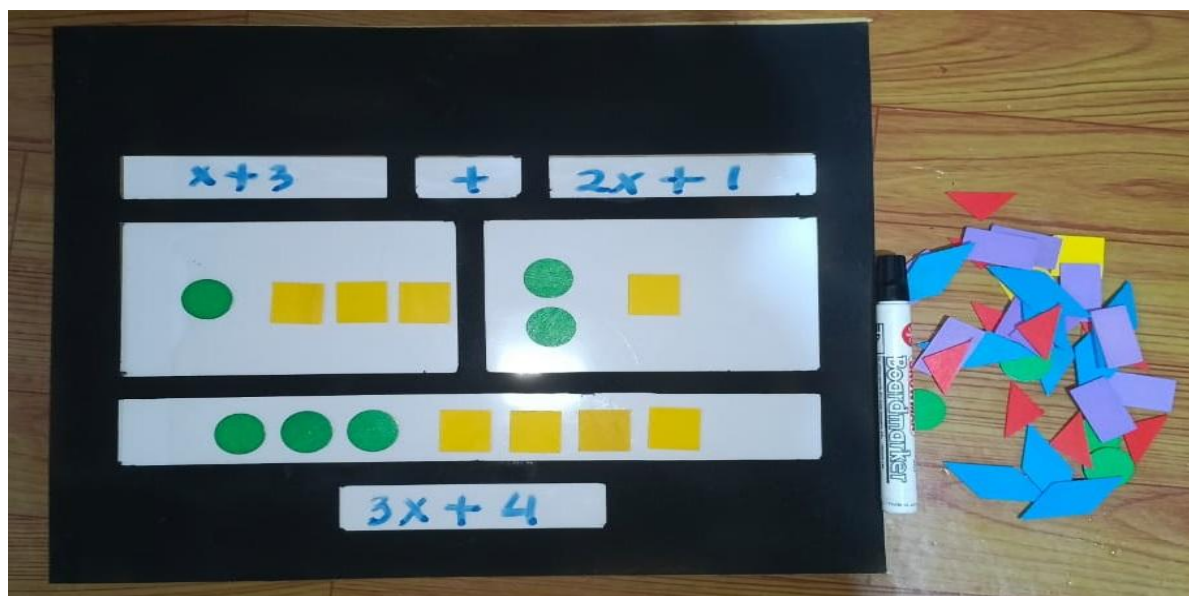


Figure 1. Initial Design of BARINJAM Media Using Cardboard Materials

After receiving feedback from the media expert and supervisors, the prototype was revised to improve symbolic clarity, visual consistency, and contextual relevance. The figure numbering also needs to be made consistent in the final manuscript. The initial

prototype should be presented as Figure 1, while the revised BARINJAM design should be presented as Figure 2. The revised version incorporated local cultural elements from Sukamara Regency and Central Kalimantan. This feature became one of the distinctive characteristics of BARINJAM because the media was not only designed as an algebra learning tool, but also as a culturally contextualized medium connected to students' local environment.



Figure 2. Revised Design of BARINJAM Media with Local Cultural Elements

The revised BARINJAM media included symbols for positive variable terms, negative variable terms, positive quadratic terms, negative quadratic terms, positive constants, and negative constants. The use of contrasting colors and culturally inspired visual forms was intended to help students distinguish each algebraic component more easily. The cultural elements did not replace the mathematical structure of the media, but functioned as contextual support to make the product more familiar and meaningful for students. This is consistent with the view that culturally contextualized learning media can increase participation, motivation, and students' sense of relevance in mathematics learning (Ardiansari et al., 2020; Ardiansari et al., 2022; Gueudet et al., 2017).

The development process followed the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation. In the analysis stage, the researcher identified curriculum demands, student characteristics, learning problems, and media needs. In the design stage, the researcher prepared the board layout, algebraic symbols, colors, operating procedures, and supporting learning materials. In the development stage, the prototype was produced and validated by experts. In the implementation stage, the media was tested through small-scale and large-scale trials. In the evaluation stage, the product was revised based on expert judgment, teacher responses, and student responses. This sequence allowed the product to be improved gradually before being used in broader classroom implementation.

Expert Validation Results

The feasibility of BARINJAM was assessed through validation by material, media, and language experts. Material validation was conducted to evaluate the suitability of the algebraic content with learning objectives, conceptual accuracy, material relevance, depth, contextuality, curiosity stimulation, and presentation. The material expert gave a score of 79 out of 79, resulting in a validation percentage of 100%. This result was

categorized as very good. It indicates that the algebraic content in BARINJAM was considered accurate, relevant, and appropriate for Grade VII learning.

Media validation assessed the product's design, visual appearance, usability, instructional suitability, symbolic clarity, and ease of use. The media expert gave a score of 45 out of 56, equivalent to 80.38%, which was categorized as good. Although this score met the feasibility criterion, it was lower than the material and language validation scores. This suggests that the physical design, visual composition, and construction quality of the media remain areas that can still be improved. The revision of the prototype was therefore necessary to strengthen the media's visual clarity and practical use in the classroom.

Language validation assessed clarity, readability, appropriateness for Grade VII students, and conformity with language standards. The language expert gave a score of 60 out of 60, resulting in a validation percentage of 100%, categorized as very good. This result indicates that the instructions, explanations, and wording used in BARINJAM were understandable and suitable for students. Language clarity is important in algebra learning because students need to understand both symbolic procedures and verbal instructions when using manipulative media.

Table 2. Expert Validation Results of BARINJAM

Validation Aspect	Score	Percentage	Category
Material validation	79/79	100%	Very good
Media validation	45/56	80.38%	Good
Language validation	60/60	100%	Very good

The validation results show that BARINJAM met the feasibility criterion established in this study. The product was feasible in terms of content accuracy, language clarity, and media quality, although improvements in physical design and durability should still be considered. These findings are in line with development research literature stating that expert validation is an important quality assurance stage before instructional media are implemented with students (Dolo & Kuai, 2023; Hamidah et al., 2023; Afandi et al., 2021; Saputri et al., 2023).

Teacher and Student Responses in Product Trials

After expert validation and revision, BARINJAM was implemented in a small-scale trial involving one mathematics teacher and 10 Grade VII students selected from classes VII A and VII B. The teacher response in the small-scale trial reached 94.73%, categorized as very feasible. This result indicates that the teacher considered BARINJAM suitable for supporting algebraic operations learning. The student response in the small-scale trial reached 88%, categorized as feasible. Students responded positively to the display, material presentation, and usefulness of the media in learning algebra.

Following the small-scale trial, the product was revised and implemented in a large-scale trial involving all 33 Grade VII students from classes VII A and VII B. The teacher response increased from 94.73% to 98.68%, showing an improvement of 3.95%. The student response also increased from 88% to 89.24%. Although the increase in student response was relatively small, the result remained positive and indicated that the revised product was accepted by students in a broader classroom setting.

Table 3. Teacher and Student Responses in Product Trials

Trial Stage	Teacher Response	Student Response	Interpretation
Small-scale trial	94.73%	88.00%	Very feasible / Feasible
Large-scale trial	98.68%	89.24%	Very feasible / Good

These results indicate that BARINJAM was practical for classroom use. The teacher's high response suggests that the media was considered useful, clear, and compatible with algebra learning activities. Students' positive responses also suggest that the media was

attractive and helpful in making algebraic operations easier to understand. This finding is important because the preliminary analysis showed that students were less engaged when algebra was taught mainly through explanation and note-taking. BARINJAM provided students with opportunities to manipulate algebraic objects, observe relationships, and connect concrete actions with symbolic notation.

The findings of this study indicate that BARINJAM is a feasible and practical learning medium for supporting Grade VII students in learning algebraic operations. The development of the media responded to a clear instructional problem: students' general numeracy achievement had improved, but their algebraic competence remained relatively low. This condition suggests that algebra learning requires instructional media that can bridge students' concrete reasoning and abstract symbolic understanding. This interpretation is consistent with previous studies explaining that Grade VII students are in a transitional stage from arithmetic thinking to algebraic reasoning, so they need support that connects concrete experiences, visual representations, and symbolic notation (Fardian et al., 2024; Kieran et al., 2016; Žakelj et al., 2024; Sun et al., 2023). BARINJAM addresses this need by transforming algebraic terms and operations into concrete visual representations that can be manipulated during learning activities.

The strong material and language validation results show that BARINJAM has adequate instructional quality. Material validation reached 100%, indicating that the algebraic content was aligned with learning objectives and considered conceptually accurate. Language validation also reached 100%, indicating that the media instructions and explanations were clear and appropriate for Grade VII students. Media validation reached 80.38%, which met the feasibility criterion but also showed that improvements in design quality remain necessary. These results support the role of expert validation as an important quality assurance process in instructional media development, particularly to ensure content accuracy, clarity of presentation, usability, and suitability for student characteristics before classroom implementation (Dolo & Kuai, 2023; Hamidah et al., 2023; Afandi et al., 2021; Saputri et al., 2023). Therefore, the media aspect should be interpreted as feasible, but still open to further refinement, especially in relation to durability, visual neatness, and ease of repeated use in classroom activities.

The teacher and student responses support the practicality of BARINJAM. The increase in teacher response after revision shows that the product became more suitable for instructional use. Students also responded positively in both trial stages, suggesting that the media was acceptable and useful from the learner perspective. This finding aligns with previous development studies showing that teacher and student response questionnaires can be used to examine practicality, usability, and acceptance of instructional media in classroom settings (Maisaroh et al., 2023; Hamidah et al., 2023; Afandi et al., 2021; Yani et al., 2023). However, these findings should not be interpreted as direct evidence of improved learning achievement. In development research, positive responses indicate practicality and user acceptance, but they are different from evidence of effectiveness in improving students' test scores or conceptual mastery. Therefore, the current findings are sufficient to support the claim that BARINJAM is feasible and practical, but effectiveness claims require complete learning outcome data.

Theoretically, the results are consistent with the concrete-representational-abstract approach. Algebra is difficult for many students because it requires them to understand that symbols represent quantities, relationships, and operations. Previous studies have shown that students often misunderstand algebraic notation, treat letters as labels rather than variables, and manipulate symbols procedurally without understanding their underlying structure (Welder, 2012; Ndemo & Ndemo, 2018; Ardiansari et al., 2020; Ardiansari et al., 2022). When students manipulate concrete objects before using symbolic notation, they can build stronger connections between

action, representation, and abstraction. This is supported by studies on concrete-representational-abstract instruction, which show that students benefit when learning moves gradually from concrete manipulation to representational models and then to formal symbols (Strickland & Maccini, 2012; Strickland, 2016; Prosser & Bismarck, 2023; Namkung & Bricko, 2020). BARINJAM follows this logic by allowing students to combine, remove, group, and organize algebraic terms before translating the process into formal algebraic expressions.

The cultural aspect of BARINJAM also adds value to the product. The name BARINJAM is inspired by the Sukamara Regency slogan “Gawi Barinjam,” which means working together to achieve noble goals. The revised visual design also integrates local cultural elements from Central Kalimantan. This cultural integration is relevant because contextual and culturally responsive learning can increase students’ participation, familiarity, and sense of ownership in mathematics learning (Ardiansari et al., 2020; Ardiansari et al., 2022; Gueudet et al., 2017). However, the cultural element should be positioned carefully. The main contribution of BARINJAM remains its function as a concrete algebra manipulative, while the cultural aspect strengthens familiarity, identity, and student engagement. In this sense, culture supports the learning experience without weakening the mathematical accuracy of the media.

Another strength of BARINJAM is its low-cost and offline nature. Many algebra learning media are digital or application-based, requiring devices, electricity, internet access, or technical skills. BARINJAM can be produced from simple materials and used directly in face-to-face learning. This makes it relevant for schools with limited technological resources. Previous studies on manipulatives and grounded representations suggest that concrete media can support mathematical understanding when they are structured around clear mathematical relationships and accompanied by teacher guidance (Koedinger et al., 2008; Goldstone et al., 2008; Gningue, 2016). However, the use of simple materials also creates a limitation, especially in terms of durability. Future development should consider stronger reusable materials so that the media can be used repeatedly in classroom practice.

A limitation of this study concerns the reporting of effectiveness. The methodology mentions learning outcome assessment through pretest and posttest procedures, but the results presented in this section focus mainly on expert validation and teacher-student responses. Therefore, the findings are sufficient to conclude that BARINJAM is feasible and practical, but they are not yet sufficient to make a strong claim about its effectiveness in improving students’ algebra achievement. To support effectiveness claims, future reports should include pretest and posttest scores, gain analysis, statistical test results, and interpretation of students’ conceptual improvement. A comparison group or quasi-experimental design would also strengthen the evidence, as commonly recommended in studies that evaluate the impact of instructional media on learning outcomes (Amir et al., 2024; Sembiring & Napitupulu, 2022; Sirait et al., 2023).

Based on the validation and trial results, BARINJAM can be recommended as a supplementary medium for Grade VII algebraic operations learning. The media is especially useful when teachers introduce variables, constants, positive and negative terms, and operations involving algebraic expressions. Teachers should use BARINJAM through a guided sequence, beginning with concrete manipulation, continuing with visual or representational explanation, and ending with formal symbolic notation. This sequence is important so that students do not stop at playing with the media, but gradually understand the mathematical meaning behind each manipulation. Such scaffolding is also consistent with the principle that concrete media do not automatically produce abstraction unless students are explicitly guided to connect physical actions with

mathematical concepts and symbols (Booth & Koedinger, 2011; Koedinger et al., 2008; Ng, 2022).

BARINJAM contributes to mathematics learning by offering a concrete, practical, low-cost, offline, and culturally contextualized medium for algebraic operations. The expert validation results show that the product is feasible, while teacher and student responses show that it is practical and positively accepted in classroom trials. The most appropriate conclusion from the current data is that BARINJAM is valid, feasible, and practical as a learning medium. Claims about effectiveness should be added only after complete learning outcome data and statistical analysis are presented.

CONCLUSION

This study concludes that BARINJAM, or Board Algebra Operations Joyful Activity in Mathematics, was successfully developed as a concrete, low-cost, offline, and culturally contextualized learning medium for Grade VII algebraic operations at SMP Negeri 1 Permata Kecubung. The development of BARINJAM responded to students' difficulty in understanding algebraic operations as abstract symbolic procedures and to the need for a manipulative medium that can represent variables, constants, positive and negative terms, and algebraic operations in a visible and meaningful way.

The validation results indicate that BARINJAM is feasible for use in mathematics learning. Material expert validation reached 100%, media expert validation reached 80.38%, and language expert validation reached 100%. These results show that the product is appropriate in terms of content accuracy, language clarity, and media quality, although the media design and physical durability can still be improved. The practicality of BARINJAM was also supported by teacher and student responses. The teacher response increased from 94.73% in the small-scale trial to 98.68% in the large-scale trial, while the student response increased from 88% to 89.24%. These findings indicate that BARINJAM was positively accepted and practical for classroom use.

Based on these findings, BARINJAM can be used as a supplementary learning medium to help students connect concrete manipulation with formal algebraic notation. Its local cultural elements provide additional contextual value by making the media more familiar and engaging for students. However, the current findings mainly support the feasibility and practicality of the product. Claims regarding its effectiveness in improving students' algebra achievement require stronger empirical evidence through complete pretest-posttest reporting, gain analysis, and statistical testing. Future research is recommended to examine the impact of BARINJAM on students' conceptual understanding and algebraic reasoning using experimental or quasi-experimental designs.

RECOMMENDATION

Based on the findings, BARINJAM is recommended as a supplementary learning medium for Grade VII algebraic operations, particularly when teachers introduce variables, constants, positive and negative terms, and operations involving algebraic expressions. Teachers are encouraged to use BARINJAM through a guided concrete-representational-abstract sequence. Students should first manipulate algebraic components concretely, then interpret the visual arrangement, and finally connect each activity with formal algebraic notation. This sequence is important to ensure that the media is not used only as a classroom activity tool, but also as a bridge toward conceptual understanding.

For classroom implementation, teachers should provide clear instructions, examples, and guided practice before students use the media independently or in groups. BARINJAM can be used in introductory lessons, remedial learning, group activities, and

concept reinforcement. Since the teacher and student responses were positive, schools may consider adopting this media in mathematics learning, especially in contexts where digital learning tools are limited or difficult to access.

Further development is also recommended to improve the physical quality of BARINJAM. The cardboard-based version is affordable and easy to produce, but its durability may be limited for repeated classroom use. Future developers should consider using stronger, reusable, and safe materials while maintaining the low-cost and hands-on characteristics of the media. The visual symbols, colors, and local cultural elements should also be refined so that the media remains attractive, mathematically accurate, and easy for students to understand.

Future research should examine the effectiveness of BARINJAM more rigorously. Subsequent studies need to report complete pretest and posttest results, learning gain analysis, and statistical test findings to determine whether the media significantly improves students' algebra achievement and conceptual understanding. Experimental or quasi-experimental designs involving comparison groups are also recommended to strengthen empirical evidence. In addition, future studies may explore the long-term impact of BARINJAM on students' algebraic reasoning and investigate the possibility of developing a digital or hybrid version without losing its concrete, low-cost, culturally contextualized, and interactive characteristics.

AUTHOR CONTRIBUTIONS

TN: Conceptualization, methodology development, investigation, data collection, data analysis, original draft preparation, data visualization, and manuscript editing. **CAP:** Supervision, methodology validation, academic mentoring, interpretation of research findings, and manuscript review and revision. **M:** Supervision, instrument and data analysis validation, research mentoring, critical manuscript review, and manuscript revision. **TE:** Supervision, conceptual development, research mentoring, manuscript content evaluation, and manuscript review and refinement. All authors have reviewed, read, and approved the final version of the manuscript and agree to its publication.

REFERENCES

- Afandi, M., Yustiana, S., & Kesuma, N. P. (2021). The development of pop-up book learning media in Pancasila materials based on local wisdom at elementary school. *Elementary Islamic Teacher Journal*, 9(1), 57–70. <https://doi.org/10.21043/elementary.v9i1.10001>
- Amir, A., Adinda, A., Sutan, T., Siregar, T., & Hariyani, N. (2024). Development of discrete mathematics module based on discovery learning for mathematical understanding in higher education. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, 10(1), 376–387. <https://doi.org/10.33394/jk.v10i1.10941>
- Ardiansari, L., Suryadi, D., & Dasari, D. (2020). The concept image of students and teachers about the equal sign. *Universal Journal of Educational Research*, 8(12), 6751–6764. <https://doi.org/10.13189/ujer.2020.081240>
- Ardiansari, L., Suryadi, D., & Dasari, D. (2022). Thinking about the equal sign: What do students see about the equal sign? *Journal of Didactic Mathematics*, 3(3), 94–109. <https://doi.org/10.34007/jdm.v3i3.1569>
- Arfika Riestyan Rachmantika, & Wardono. (2019). Peran kemampuan berpikir kritis siswa pada pembelajaran matematika dengan pemecahan masalah. *PRISMA, Prosiding Seminar Nasional Matematika*, 2, 439–443.

- Armayanti, A., & Nasution, I. S. (2024). Development of maths booklet media for primary school students. *Edunesia: Jurnal Ilmiah Pendidikan*, 5(2), 714–731. <https://doi.org/10.51276/edu.v5i2.847>
- Arsyad, A. (2017). *Media pembelajaran*. Rajawali Pers.
- Birgin, O., & Demirören, K. (2025). Seventh-grade students' views regarding enriched algebra instruction (EAI) supported by technology and manipulatives. *Journal of Computer Assisted Learning*, 41(5). <https://doi.org/10.1111/jcal.70100>
- Booth, J. L., & Koedinger, K. R. (2011). Are diagrams always helpful tools? Developmental and individual differences in the effect of presentation format on student problem solving. *British Journal of Educational Psychology*, 82(3), 492–511. <https://doi.org/10.1111/j.2044-8279.2011.02041.x>
- Cahyadi, R. A. H. (2019). Pengembangan bahan ajar berbasis ADDIE model. *Halaqa: Islamic Education Journal*, 3(1), 35–42. <https://doi.org/10.21070/halaqa.v3i1.2124>
- Dolo, F. X., & Kuai, M. Y. (2023). Development of hybrid audiovisual e-book with local wisdom-based real-world problems in Ngada's Wela Maka. *IJILS*, 1(2), 61–70. <https://doi.org/10.25078/ijils.v1i2.3181>
- Damayanti, et al. 2018. *Kelayakan Media Pembelajaran Fisika Berupa Buku Saku Android pada Materi Fluida Statis*. *Indonesian Journal of Science and Mathematics Education*, 1(1), 63–70.
- Fardian, D., Suryadi, D., Prabawanto, S., & Hayuningrat, S. (2024). Research trends on early algebra in the middle school: A combined bibliometric and meta-analysis review. *Jurnal Elemen*, 10(2), 410–440. <https://doi.org/10.29408/jel.v10i2.25539>
- Gningue, S. M. (2016). Remembering Zoltan Dienes, a maverick of mathematics teaching and learning: Applying the variability principles to teach algebra. *International Journal for Mathematics Teaching and Learning*, 17(2). <https://doi.org/10.4256/ijmtl.v17i2.17>
- Goldstone, R. L., Landy, D., & Son, J. Y. (2008). A well-grounded education: The role of perception in science and mathematics. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 327–356). Cambridge University Press. <https://doi.org/10.1093/acprof:oso/9780199217274.003.0016>
- Gueudet, G., Bosch, M., diSessa, A. A., Kwon, O. N., & Verschaffel, L. (2017). Transitions in mathematics education: The panel debate. In G. Gueudet, M. Bosch, S. diSessa, O. N. Kwon, & L. Verschaffel (Eds.), *Transitions in mathematics education* (pp. 101–117). Springer. https://doi.org/10.1007/978-3-319-62597-3_7
- Hamidah, A., Ayunasari, D. S., & Sanjaya, E. (2023). Development of E-LKPD in motion system materials for high school class using PageFlip 3D software. *Jurnal Penelitian Pendidikan IPA*, 9(3), 1233–1241. <https://doi.org/10.29303/jppipa.v9i3.3396>
- Khadijah. (2016). *Perkembangan kognitif anak usia dini: Teori dan praktik*. Perdana Publishing.
- Kieran, C., Jeongsuk, P., Schifter, D., & Ng, S. F. (2016). *Early algebra*. Springer. <https://doi.org/10.1007/978-3-319-32258-2>
- Koedinger, K. R., Alibali, M. W., & Nathan, M. J. (2008). Trade-offs between grounded and abstract representations: Evidence from algebra problem solving. *Cognitive Science*, 32(2), 366–397. <https://doi.org/10.1080/03640210701863933>
- Maisaroh, K., Laila, A., & Basori, M. (2023). Kapin (smart card) media: Evaluating learning tools efficacy to improve reading skills of second grads. *Utamax Journal of Ultimate Research and Trends in Education*, 5(3), 246–256. <https://doi.org/10.31849/utamax.v5i3.15020>
- Marni, R., & Pasaribu, L. H. (2021). Peranan matematika dalam kehidupan sehari-hari. *Jurnal Pendidikan dan Matematika*, 10(2), 45–53.

- Namkung, J. M., & Bricko, N. (2020). The effects of algebraic equation solving intervention for students with mathematics learning difficulties. *Journal of Learning Disabilities*, 54(2), 111–123. <https://doi.org/10.1177/0022219420930814>
- Ndemo, Z., & Ndemo, O. (2018). Secondary school students' errors and misconceptions in learning algebra. *Journal of Education and Learning (EduLearn)*, 12(4), 690–701. <https://doi.org/10.11591/edulearn.v12i4.9556>
- Ng, S. F. (2022). The model method: Crown jewel in Singapore mathematics. *Asian Journal for Mathematics Education*, 1(2), 147–161. <https://doi.org/10.1177/27527263221107526>
- Nuraina, N., Muliana, M., Nufus, H., & Zahara, S. R. (2022). Developing students' worksheet based Missouri Mathematics Project with the integration of students local wisdom in teaching mathematics and physics. *Jurnal Penelitian Pendidikan IPA*, 8(1), 147–155. <https://doi.org/10.29303/jppipa.v8i1.1134>
- Özcan, Z. Ç. (2024). Evaluating the impact of the WEI4S instructional approach on middle school students' algebraic problem-solving skills. *Education Sciences*, 14(1), Article 102. <https://doi.org/10.3390/educsci14010102>
- Prosser, S. K., & Bismarck, S. F. (2023). Concrete-representational-abstract (CRA) instructional approach in an Algebra I inclusion class: Knowledge retention versus students' perception. *Education Sciences*, 13(10), Article 1061. <https://doi.org/10.3390/educsci13101061>
- Risnawati, R., Andrian, D., Azmi, M. P., MZ, Z. A., & Nurdin, E. (2019). Development of a definition maps-based plane geometry module to improve the student teachers' mathematical reasoning ability. *International Journal of Instruction*, 12(3), 541–560. <https://doi.org/10.29333/iji.2019.12333a>
- Saputri, N. S. D., Izzaty, R. E., & Aryani, E. (2023). Design of social anxiety measurement tools for user of social media. In *Proceedings of the International Conference* (pp. 126–133). Atlantis Press. https://doi.org/10.2991/978-2-38476-030-5_15
- Sembiring, B. O., & Napitupulu, E. E. (2022). Development of interactive student's worksheets to improve mathematical HOTS of tenth grade students in trigonometry topic. *Alphamath Journal of Mathematics Education*, 8(2), 99–108. <https://doi.org/10.30595/alphamath.v8i2.14363>
- Sirait, S., Syafitri, E., & Nisa, K. (2023). The development of animation-based learning on students' numeracy literacy skills. *Al-Ishlah: Jurnal Pendidikan*, 15(2), 1696–1705. <https://doi.org/10.35445/alishlah.v15i2.2858>
- Strickland, T. K. (2016). Using the CRA-I strategy to develop conceptual and procedural knowledge of quadratic expressions. *Teaching Exceptional Children*, 49(2), 115–125. <https://doi.org/10.1177/0040059916673353>
- Strickland, T. K., & Maccini, P. (2012). The effects of the concrete-representational-abstract integration strategy on the ability of students with learning disabilities to multiply linear expressions within area problems. *Remedial and Special Education*, 34(3), 142–153. <https://doi.org/10.1177/0741932512441712>
- Sugiyono. (2017). *Metode penelitian dan pengembangan (Research and Development/R&D)*. Alfabeta.
- Sukmadinata, N. S. (2015). *Metode penelitian pendidikan*. Remaja Rosdakarya.
- Sumarni, S., Adiastuty, N., Riyad, M., Fisabqi, N., & Pritiya, W. (2022). Development of geometry teaching materials assisted Geogebra Android to improve mathematical connection ability. *EAI Proceedings*. <https://doi.org/10.4108/eai.2-12-2021.2320201>
- Sun, S., Sun, D., & Xu, T. (2023). The developmental progression of early algebraic thinking of elementary school students. *Journal of Intelligence*, 11(12), Article 222. <https://doi.org/10.3390/jintelligence11120222>

- Trgalová, J., Bouhineau, D., & Nicaud, J.-F. (2009). An analysis of interactive learning environments for arithmetic and algebra through an integrative perspective. *International Journal of Computers for Mathematical Learning*, 14(3), 299–331. <https://doi.org/10.1007/s10758-009-9155-9>
- Welder, R. M. (2012). Improving algebra preparation: Implications from research on student misconceptions and difficulties. *School Science and Mathematics*, 112(4), 255–264. <https://doi.org/10.1111/j.1949-8594.2012.00136.x>
- Yani, K. E. M., Parji, P., & Dewi, C. (2023). Educational game media based on CAI in PPKn for fourth grade elementary school. *JPI (Jurnal Pendidikan Indonesia)*, 12(4), 690–704. <https://doi.org/10.23887/jpiundiksha.v12i4.65037>
- Younes, L. M., Ismail, M. M., & Achtaich, N. (2020). A didactic balance to solve equations. *Advances in Science, Technology and Engineering Systems Journal*, 5(5), 288–294. <https://doi.org/10.25046/aj050536>
- Žakelj, A., Cotič, M., & Doz, D. (2024). Demetriou's tests and levels of algebraic abilities and proportional reasoning in seventh, eighth, and ninth grades. *European Journal of Science and Mathematics Education*, 12(2), 326–334. <https://doi.org/10.30935/scimath/14460>