Articulate Storyline-based interactive media: An ADDIE-model development for algebraic operation learning

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ABSTRACT

Students' difficulties in understanding algebraic operations, particularly in translating contextual problems into symbolic expressions, highlight the need for instructional media that support visualisation, structured scaffolding, and active engagement. This study aimed to develop and evaluate Articulate Storyline-based interactive media for learning algebraic operations using the ADDIE model (analysis, design, development, implementation, and evaluation). Data were collected through expert validation sheets, student practicality questionnaires, and post-test assessments, and analysed using descriptive statistical techniques (mean scores and percentage distributions). The product was implemented in three stages: one-to-one testing (3 students), small-group testing (8 students), and a field trial involving 18 seventh-grade students. Expert validation indicated that the media was highly valid across content accuracy, contextual suitability, presentation quality, and instructional design. Practical results showed positive student responses regarding usability and engagement. The post-test mean score was 82, and all students achieved medium to very high performance, indicating potential improvement in conceptual understanding. This study contributes to mathematics education by providing an empirically validated multimedia design that integrates contextual animation, step-by-step symbolic visualisation, and interactive feedback to address abstraction challenges in algebra learning.

INTRODUCTION

The transformation of education in the era of the Industrial Revolution 4.0 has positioned digital technology as a strategic foundation of 21st-century learning. The Education 4.0 paradigm requires instructional approaches that are adaptive, personalised, and engaging, supported by meaningful technological integration (Khanna et al., 2024; Moraes et al., 2023). The adoption of digital tools such as authoring platforms, learning management systems, and gamification-based media has been widely recognised as essential for improving student engagement and learning effectiveness (Alenezi et al., 2023; Chiappe et al., 2024). Empirical evidence further indicates that successful technology integration depends not only on infrastructure availability but also on pedagogically grounded instructional design and teacher readiness (Timotheou et al., 2023). These

findings suggest that systematic instructional development models must accompany digital transformation in education to ensure alignment between technological affordances and learning objectives.

This transformation particularly influences mathematics education due to its abstract and symbolic characteristics. As a discipline that emphasises logical reasoning and structural thinking, mathematics requires instructional strategies that bridge conceptual abstraction with meaningful representation (Loyens et al., 2023). Algebra, as a foundational topic in secondary education, demands students' ability to manipulate symbolic expressions and translate contextual situations into mathematical models. Research consistently documents persistent student difficulties in generalisation, symbolization, and procedural fluency in algebra (Chance et al., 2024; Oh & Han, 2022). Without adequate instructional support, these challenges often result in misconceptions and superficial understanding (Gilmore, 2023), particularly when classroom instruction lacks visual scaffolding and interactive engagement (Monteleone et al., 2023). Such conditions reinforce the need for interactive multimedia environments that facilitate conceptual visualisation, structured practice, and formative feedback.

Among various authoring platforms, Articulate Storyline has emerged as a promising tool for designing multimedia-based interactive learning environments that integrate text, animation, simulation, and automated feedback (Mand et al., 2024; Yorganci, 2022). Prior studies report that integrating Articulate Storyline in mathematics instruction improves conceptual understanding and classroom participation (Simarmata & Siregar, 2024), while also enhancing student independence and learning motivation (Putri et al., 2022). Additional evidence demonstrates its effectiveness in supporting conceptual mastery in higher-level mathematical topics such as calculus (Jazuli et al., 2024). Beyond mathematics, the validity and instructional feasibility of Articulate Storyline-based media have also been demonstrated in science learning at the junior secondary level, further affirming its cross-disciplinary applicability as an interactive learning platform (Setiawan & Rahman, 2025). Nevertheless, most of these studies primarily emphasise the product development and expert validation stages. Empirical examination of the practicality of classroom-based instruction and its measurable learning outcomes remains limited. A bibliometric review by Muhammad et al., (2023) confirms that research on Articulate Storyline has rarely progressed to systematic field implementation and impact measurement. Consequently, robust empirical evidence of its instructional effectiveness in authentic algebra classrooms at the junior secondary level remains insufficient.

Responding to this identified gap, the present study develops interactive mathematics learning media using Articulate Storyline to support algebraic form operations for junior secondary students, guided by the ADDIE development model (Branch, 2009; Julia et al., 2023). The study pursues three interrelated objectives. First, to evaluate the validity of the developed media through expert review to ensure content, design, and pedagogical alignment. Second, to examine its practicality based on student responses during staged classroom implementation. Third, to investigate its potential impact on students' conceptual understanding of algebraic operations as reflected in learning outcome measures. By extending prior development-oriented research toward systematic classroom evaluation and outcome-based analysis, this study contributes empirical evidence concerning the feasibility, usability, and instructional value of Articulate Storyline-based media. Furthermore, the research aligns with the implementation of the *Kurikulum Merdeka*, which emphasises contextualised and technology-enhanced learning practices (Ndari et al., 2023), thereby offering theoretical enrichment and practical guidance for reforming mathematics education.

METHOD

This study adopted an educational design research approach, employing the ADDIE instructional development model (Analysis, Design, Development, Implementation, and Evaluation) as its systematic procedural framework. The ADDIE model was selected over alternative development models due to its iterative, evaluation-driven structure that enables continuous refinement at each stage, its well-documented applicability in technology-integrated instructional

design, and its alignment with the quality indicators of validity, practicality, and learning impact targeted in this study (Branch, 2009; Jannah et al., 2023; Mukti et al., 2024). The research aimed to produce Articulate Storyline-based interactive learning media for algebraic form operations that meet established criteria for instructional validity and classroom practicality, while demonstrating potential improvements in student learning outcomes.

The study was conducted at Junior High School Number 2 Sungai Lilin during the first semester of the 2024/2025 academic year. Participants were selected through purposive sampling based on two primary criteria: students enrolled in Grade VII who were currently studying algebraic form operations as part of the national mathematics curriculum, and schools with basic digital infrastructure but that had not previously implemented interactive digital learning media in mathematics instruction. Expert validators comprised four individuals: three mathematics education lecturers with substantial experience in the design and development of digital learning media, and one practising mathematics instructional teacher with extensive classroom teaching experience at the junior secondary level. The implementation stage involved three sequential phases of student trials: a one-to-one trial (n = 3), a small group trial (n = 8), and a field test (n = 18 Grade VII students). Table 1 presents the full participant profile across all research stages.

Table 1. Research Participants at Each Stage

No.	Stage	Participant Profile	n
1	Expert Validation	Mathematics education lecturers (instructional design and digital media)	2
2	Expert Validation	Practising mathematics teacher (junior secondary level)	2
3	One-to-One Trial	Grade VII students	3
4	Small Group Trial	Grade VII students	8
5	Field Test	Grade VII students	18

Prior to data collection, formal written permission was obtained from the principal of Junior High School Number 2 Sungai Lilin. Informed consent was secured from all participating students and their parents or guardians. Participants were informed that their involvement was entirely voluntary, that they could withdraw at any time without consequences, and that all data collected would be used exclusively for academic research and reported in anonymised form.

Figure 1 presents the overall development procedure, illustrating the sequential, iterative flow through the five ADDIE stages.
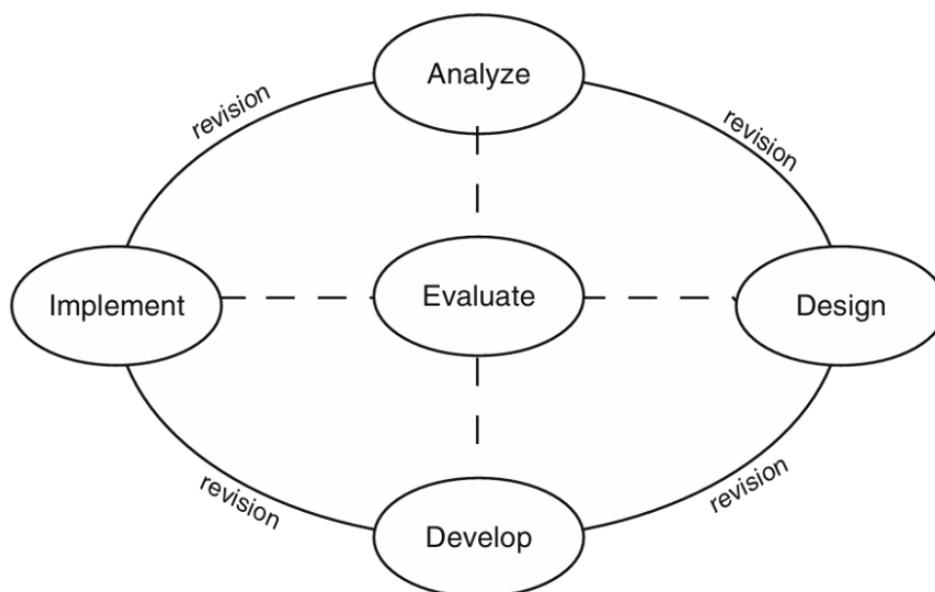

Figure 1. ADDIE Model Development Procedure in this Study

The development procedure followed the five ADDIE stages as illustrated in Figure 1. At the analysis stage, the researcher conducted a curriculum review of the *Kurikulum Merdeka* to identify

relevant learning competencies for algebraic operations, complemented by semi-structured interviews with the mathematics teacher and classroom observations to establish the instructional needs and learner characteristics profile (Wang, 2024). Identified needs included students' difficulties with symbolic abstraction, absence of visual scaffolding, and lack of interactive digital media in classroom practice. During the design stage, a detailed storyboard was developed to map content sequencing, interface navigation, and instructional interaction flows. Content was aligned with curriculum objectives and enriched with visual, animated, and contextual elements following multimedia learning principles (Mayer, 2009). Research instruments were also developed and validated at this stage (Sun, 2024).

During development, a media prototype was built in Articulate Storyline, incorporating flexible navigation, formative quizzes with automated feedback, contextual learning scenarios, audio narration, and character-based animations. The prototype was submitted to four expert validators using a structured Likert-scale rubric (1–4) covering four dimensions: content accuracy, visual presentation, contextual suitability, and instructional design innovation. Qualitative comments from validators informed iterative revisions to the media's language, interface, and technical features (Koszalka & Whorway, 2025; Timbi-Sisalima et al., 2024). To ensure consistency of evaluation across validators, an inter-rater agreement procedure was employed. Each validator independently assessed the media using the same structured rubric, and discrepant ratings were resolved through a structured discussion session to reach a consensual judgment.

The implementation stage consisted of three sequential phases. The one-to-one trial (n = 3) identified initial technical obstacles and evaluated navigation clarity. Following minor revisions, the small-group trial (n = 8) assessed the independent usability and coherence of interactive components. The field test (n = 18) was then conducted across four structured sessions of 2×40 minutes each, during which students accessed the media individually via mobile devices with minimal teacher guidance (Martín-Sómer et al., 2024). The evaluation stage incorporated both formative and summative components. Formative evaluation was embedded throughout each ADDIE stage to enable continuous media refinement (Shakeel et al., 2023), while summative evaluation assessed three quality indicators: validity, practicality, and potential impact on learning outcomes.

Three instruments were used for data collection, as summarised in Table 2. The expert validation sheet assessed four dimensions of media quality using a four-point Likert scale. The student practicality questionnaire measured perceived usability, navigation clarity, visual appeal, and content engagement. The post-test comprised items targeting conceptual understanding of algebraic form operations, administered following the field test phase. All instruments were developed based on established theoretical frameworks and reviewed for content validity by the expert validators before use.

Table 2. Research Instruments

No.	Instrument	Dimensions Assessed	Respondents	Scale
1	Expert Validation Sheet	Content accuracy, visual presentation, contextual suitability, and instructional design	4 Validators	Likert 1–4
2	Student Practicality Questionnaire	Usability, navigation, visual appeal, and content engagement	18 Students	Likert 1–4
3	Post-Test	Conceptual understanding of algebraic operations	18 Students	0–100

Data were analysed using descriptive statistical techniques, with results expressed as mean scores and percentage distributions. Media validity was determined by converting expert ratings into percentage scores, with a minimum threshold of 70% required for the media to be classified as valid (Adiastuti et al., 2025; Astuti et al., 2022). Practicality was similarly assessed through student questionnaire responses, with a minimum threshold of 60% required to classify the media as practical. Post-test scores were categorised into five performance levels as presented in Table 3. Given that this study represents an initial product development phase, inferential statistical procedures were not applied, and outcome findings are interpreted as indicative of potential instructional impact rather than causal evidence (Shakeel et al., 2023).

Table 3. Post-Test Score Classification Criteria

| No.	Score Range	Category
1	$86 < X \leq 100$	Very High
2	$71 < X \leq 86$	High
3	$56 < X \leq 71$	Moderate
4	$26 < X \leq 56$	Low
5	Below 26	Very Low

RESULTS AND DISCUSSION

Results

The development of Articulate, a study on Storyline-based interactive learning media for algebraic form operations, using the ADDIE model, yielded findings across three quality dimensions: validity, potential effect on student learning outcomes, and practicality.

At the analysis stage, interviews with the mathematics teacher and review of learning documents confirmed that students experienced significant difficulties in understanding abstract algebraic concepts, particularly in relating algebraic symbols to contextual situations. Classroom instruction remained predominantly conventional, with no digital media available to support concept visualisation or active student engagement. These findings established the instructional need that guided subsequent design and development.

At the design stage, four main media components were planned in accordance with multimedia learning principles (Mayer, 2009), as presented in Figure 2.
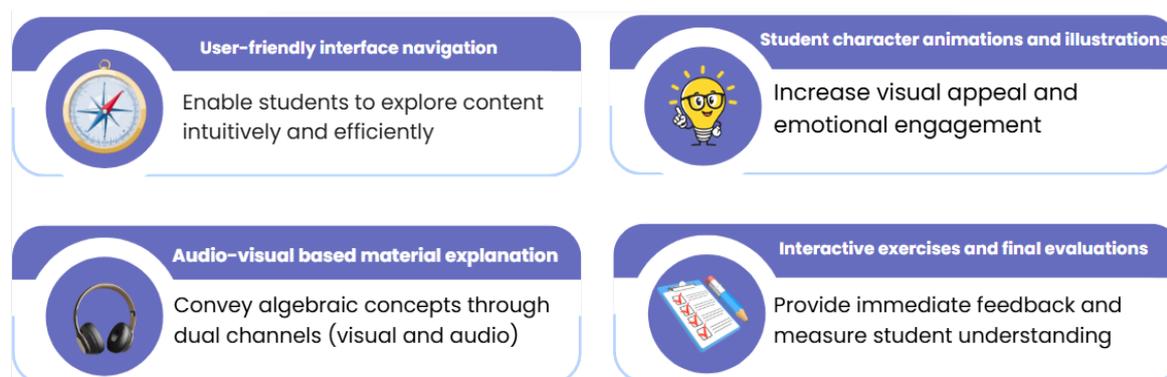
Figure 2. Design Components of Articulate Storyline-Based Interactive Learning Media

At the development stage, the media prototype was validated by four experts using a Likert-scale instrument (1–4) covering four dimensions: content feasibility, display presentation, context suitability, and media innovation. The validation results are presented in Table 4. The total average score of 3.73, equivalent to 93.25%, exceeds the minimum validity threshold of 70%, placing the media in the highly valid category across all assessed dimensions.

Table 4. Learning Media Validation Results

No.	Aspects Assessed	Average Score	Percentage (%)	Category
1	Content Feasibility	3.75	93.75	Highly Valid
2	Display Presentation	3.67	91.75	Highly Valid
3	Context Suitability	3.83	95.75	Highly Valid
4	Media Innovation	3.67	91.75	Highly Valid
Total Average		**3.73**	**93.25**	**Highly Valid**

The prototype of the developed media, as illustrated in Figure 3, demonstrates the integration of visual, audio, and interactive components across the main learning interface.

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Figure 3. Interactive Media Development Prototype

At the implementation stage, the media was trialled in three sequential phases involving Grade VII students. The one-to-one trial (n = 3) identified initial technical obstacles and evaluated navigation clarity. The small-group trial (n = 8) assessed the independent usability and coherence of interactive components. The field test (n = 18) was conducted across four structured sessions of 2 × 40 minutes each, with students accessing the media individually via mobile devices. Figure 4 illustrates the implementation process across all three trial phases.

Figure 4. Implementation Stages: One-to-One, Small Group, and Field Test

Post-test results from the field test phase are presented in Table 5. The average post-test score was 82, placing the media in the very high category. The score distribution indicates that all students achieved at least the moderate performance threshold, with none falling into the low category.

Table 5. Distribution of Students' Post-Test Scores

No.	Score Range	Number of Students	Percentage (%)	Category
1	$86 < X \leq 100$	8	44.4	Very High
2	$71 < X \leq 86$	6	33.3	High
3	$56 < X \leq 71$	4	22.2	Moderate
4	$26 < X \leq 56$	0	0	Low
Total		**18**	**100**	**-**

At the evaluation stage, practicality was assessed through student response questionnaires. The average score of 74 out of a maximum of 85, equivalent to 87.06%, exceeds the minimum practicality threshold of 60%, placing the media in the practical category. Figure 5 presents the percentage distribution of student practicality score categories.
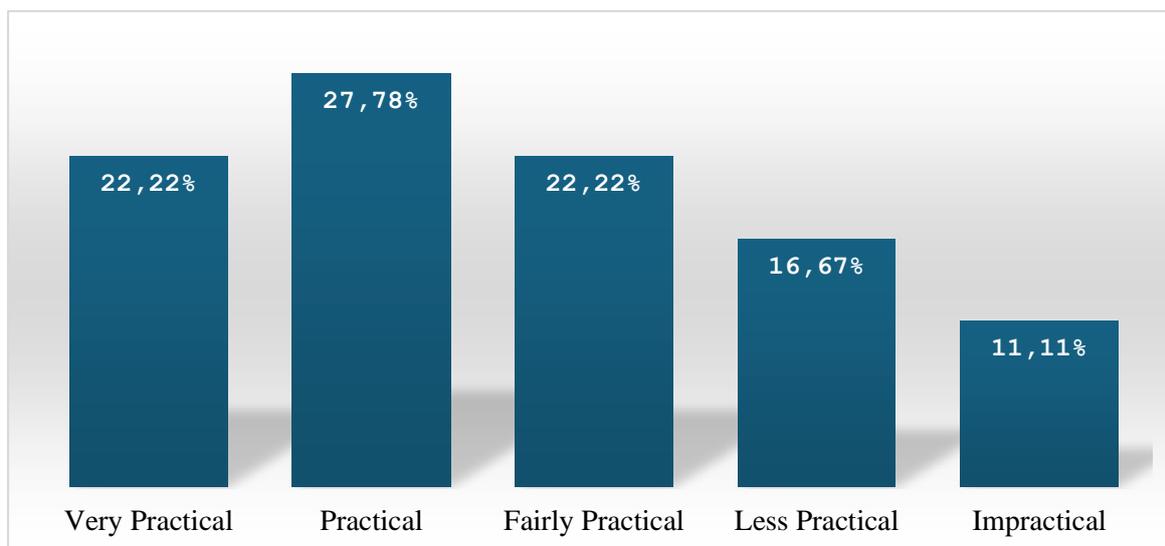

Figure 5. Percentage Distribution of Students' Practicality Score Categories

Discussion

The expert validation results, with an average score of 3.73 (93.25%) across all four assessed dimensions, confirm that the developed media meets established standards of instructional validity. This finding is consistent with those reported by Mukti et al., (2024) and Jannah et al., (2023), who similarly obtained highly valid ratings for Articulate Storyline-based media in mathematics learning contexts, and with Simarmata & Siregar (2024), who documented comparable validation outcomes in a junior secondary mathematics setting. The consistency of these findings across multiple studies suggests that Articulate Storyline, when developed through a systematic instructional design process, reliably produces media that meet content, visual, and pedagogical quality standards. Notably, context suitability received the highest rating among all assessed dimensions, indicating that the media successfully bridges abstract algebraic concepts with contextually meaningful representations and directly addresses one of the core learning difficulties identified during the analysis stage.

"Beyond mathematics, the validity and instructional feasibility of Articulate Storyline-based media have also been demonstrated in science learning at the junior secondary level, further affirming its cross-disciplinary applicability as an interactive learning platform (Setiawan & Rahman, 2025)."

The validity outcomes of this study are further grounded in established instructional design theory. Dick et al., (2015) emphasise that a valid instructional product must demonstrate strong alignment between content, learning objectives, and delivery strategies, a standard that the present media demonstrably meets across all assessed dimensions. Shakeel et al., (2023) affirm that rigorous expert validation is essential for ensuring the pedagogical soundness of digital learning media before classroom implementation, reinforcing the importance of the validation process undertaken in this study. Furthermore, Sun (2024) and Wang (2024) demonstrate that iterative validation cycles within the ADDIE model produce learning products that are more responsive to learner needs, a pattern clearly evident in the continuous refinement process that shaped the final media prototype.

The post-test results, with an average score of 82 and all students achieving at least the moderate performance level, indicate that the developed media has meaningful potential to support students' conceptual understanding of algebraic form operations. This is a significant finding. These results align with those of Julia et al., (2023), Jannah et al., (2023), and Mukti et al., (2024), who consistently documented improvements in mastery of mathematical concepts following the use of Articulate Storyline-based media, particularly in abstract symbolic topics where conventional instruction often falls short. The convergence of these findings across independent studies

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strengthens the case that interactive multimedia environments, when designed with clear pedagogical intent, can effectively address the abstraction challenges that characterise algebra learning at the junior secondary level.

The media's effectiveness in supporting learning outcomes reflects the coherence between its instructional design and established cognitive learning principles. Mayer (2009) multimedia learning theory posits that instructional media integrating visual, auditory, and interactive channels reduces cognitive load through dual-channel processing and strengthens the integration of verbal and visual information. The present media operationalises these principles through step-by-step symbolic visualisation, contextual character animations, and automated formative feedback, collectively enabling students to construct conceptual schemata through repeated, structured interactions with the content. Davenport et al., (2023) further demonstrate that visualisation-based approaches in algebra learning help students build accurate mental representations of mathematical expression structures, while Chang & Lin (2024) report significant impacts of visual learning systems on conceptual understanding across diverse learner profiles, including those with learning difficulties. These theoretical and empirical perspectives confirm that the media's capacity to support conceptual understanding derives from the pedagogical coherence of its design, which systematically aligns visual scaffolding, interactive practice, and formative feedback to facilitate progressive concept formation in algebraic reasoning.

The practicality evaluation yielded an average score of 74 out of 85 (87.06%), exceeding the minimum threshold of 60% and indicating that the media was perceived as practical by the majority of students. This result is consistent with Putri et al., (2022), who reported positive student practicality responses to Articulate Storyline-based media in a mathematics learning context, and with Martín-Sómer et al., (2024), who similarly found that interactive media enhances learning efficiency and user satisfaction in specific subjects. Adiastuti et al., (2025) further corroborate this pattern, reporting validity ratings exceeding 90% and a practicality level of 91.33% for an ADDIE-developed digital learning material in a junior secondary mathematics context. The positive practicality perceptions observed in this study are attributable to the media's interface usability, navigation clarity, and visual engagement, which align with Alqurni (2023) assertion that intuitively designed interfaces reduce cognitive burden and improve user comfort. Hongsuchon et al., (2022) further demonstrate that media designs that facilitate active engagement and perceived accessibility directly contribute to increased motivation and learning outcomes, a pattern consistent with the predominantly positive student responses recorded in this study.

The convergence of high validity, strong learning-outcome indicators, and positive practicality perceptions collectively demonstrates that the developed media constitute a pedagogically sound and contextually applicable instructional resource for algebra learning at the junior secondary level. These findings collectively affirm that interactive multimedia environments, when grounded in systematic instructional design and informed by cognitive learning principles, can effectively address the abstraction challenges inherent in algebra instruction at this level.

These findings carry meaningful implications across theoretical, practical, and policy dimensions. Theoretically, the results strengthen constructivist and cognitivist frameworks for instructional media development, demonstrating that visually scaffolded, interactively structured, and contextually grounded media can facilitate conceptual understanding in abstract mathematical domains (Dick et al., 2015; Mayer, 2009). In practice, mathematics teachers can adopt this media as an alternative instructional resource that supports both classroom-based and independent technology-enhanced learning, in alignment with the contextualized and technology-driven pedagogical emphases of the *Kurikulum Merdeka* (Ndari et al., 2023). At the policy level, the findings underscore the importance of institutional support from schools and education authorities in enabling the systematic development and adoption of digital learning media that are responsive to learner characteristics and aligned with national educational technology priorities.

Several limitations of this study must be acknowledged, though they do not diminish its contributions. First, the trial was conducted with 18 students from a single school, limiting the generalizability of the findings to broader, more diverse educational contexts. Nevertheless, the results provide meaningful initial evidence of the media's instructional potential within the studied

setting. Second, the absence of a control group and a pretest means that the observed learning outcomes can be interpreted only as indicative of the media's potential instructional impact rather than as causal evidence of its effectiveness, highlighting the need for more rigorous experimental designs in subsequent research. Third, the practicality evaluation relied solely on student responses, without triangulation from teacher or educational technology expert perspectives, which limits the comprehensiveness of the usability assessment and the conclusions that can be drawn about the media's readiness for broader classroom adoption.

These limitations point to clear directions for future research. Subsequent studies are recommended to employ quasi-experimental designs with pretest-posttest control-group structures to provide more rigorous evidence of instructional effectiveness. Implementation should be extended across diverse school settings and learner profiles to strengthen the generalizability of the findings. In addition, teacher and expert perspectives should be incorporated into practicality evaluations to provide a more comprehensive assessment of media usability. Finally, responsive media designs optimized for varied digital device environments should be developed to address the technical compatibility issues identified in this study.

CONCLUSION

This study successfully developed Articulate Storyline-based interactive learning media for algebraic form operations using the ADDIE model and evaluated them across three quality dimensions. Expert validation confirmed that the media is highly valid in terms of content accuracy, contextual suitability, visual presentation, and instructional design, with a total average score of 3.73. Student responses indicated that the media is practical, with an average practicality score of 74, reflecting positive perceptions of usability and engagement. Post-test results demonstrated the media's potential to improve learning outcomes, with an average score of 82 and all students achieving at least the moderate category, indicating meaningful conceptual gains in algebraic operations.

This study contributes empirical evidence that systematically developed multimedia learning environments, grounded in the ADDIE model and informed by multimedia learning theory, can effectively address abstraction challenges in junior secondary mathematics education. These findings extend prior development-oriented research by demonstrating the feasibility, usability, and instructional value of Articulate Storyline-based media in authentic classroom settings.

Future research is recommended to employ quasi-experimental designs with pretest-posttest control-group structures to establish causal evidence of instructional effectiveness, extend implementation across diverse school contexts, incorporate teacher perspectives in practicality evaluations, and develop responsive media designs optimized for varied digital devices.

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