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Development of Programming-Based Learning Media on Geometry Material for Grade IV Elementary School Assisted by Scratch Application

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Abstract: Mathematics is a fundamental discipline that plays a crucial role in everyday life and education, fostering essential cognitive skills such as logical reasoning, critical thinking, and problem-solving. Despite its importance, many students perceive mathematics as challenging, abstract, and disengaging, often leading to diminished motivation and suboptimal learning outcomes. This study addresses these challenges by developing and evaluating a programming-based learning media focused on Geometry material for Grade IV elementary students, utilizing the Scratch application to create an interactive and gamified learning environment. The primary objective is to assess the validity and effectiveness of this Scratch-assisted learning media in enhancing students' understanding of Geometry concepts while simultaneously supporting character education through the integration of Pancasila values. Employing a Research and Development (R&D) methodology grounded in the ADDIE model—comprising Analysis, Design, Development, Implementation, and Evaluation phases—this study systematically designs and tests the learning media. Data collection involved needs assessments through surveys and interviews, media trials with students, and pre-test and post-test evaluations to measure learning gains. Statistical analysis using paired sample t-tests demonstrated a significant improvement in students' comprehension of Geometry material after using the Scratch-based media. Furthermore, the media's gamification elements, case study-based questions, and automated assessment features effectively increased student motivation and engagement, fostering a positive learning atmosphere. The findings underscore the potential of Scratch as a versatile educational tool that not only enhances cognitive learning outcomes but also promotes character development aligned with Pancasila values. This research contributes to the growing body of evidence supporting technology-enhanced learning in elementary education and offers practical implications for educators seeking innovative methods to improve mathematics instruction. The study also highlights opportunities for expanding the application of programming-based learning media to other subjects and age groups, encouraging further exploration into the integration of technology, gamification, and character education in diverse educational contexts.

Keywords: Geometry material, ADDIE, Mathematics, Elementary School, Scratch

1. Introduction

Mathematics is universally recognized as a foundational discipline that underpins not only academic achievement but also practical problem-solving and critical thinking skills essential for everyday life. Its role extends beyond mere number manipulation to fostering logical reasoning, analytical thinking, and the ability to approach complex problems systematically. These cognitive skills are vital for students' intellectual development and their capacity to navigate an increasingly complex and technology-driven world. Consequently, mathematics is mandated as a compulsory subject

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across all educational levels worldwide, reflecting its significance in shaping well-rounded, competent individuals capable of contributing meaningfully to society (Snow, 2019).

Despite its importance, mathematics education faces persistent challenges, particularly in engaging young learners and facilitating their comprehension of abstract concepts. Many students perceive mathematics as difficult, intimidating, and disconnected from their daily experiences, often resulting in anxiety, disinterest, and poor academic performance. This perception is especially pronounced when students encounter abstract topics such as geometry, which require transitioning from concrete, tangible experiences to more symbolic and spatial reasoning. The cognitive leap from concrete to abstract thinking is a well-documented hurdle in early mathematics education, necessitating innovative pedagogical approaches and effective learning media to bridge this gap.

Learning media serve as critical tools in this context, acting as intermediaries that translate abstract mathematical ideas into accessible, concrete representations. Effective learning media can enhance students' conceptual understanding by providing visual, interactive, and contextualized experiences that stimulate engagement and facilitate knowledge construction (Etyarisky & Marsigit, 2022). However, the development and deployment of such media require not only technological resources but also pedagogical expertise to ensure alignment with curriculum goals and learners' cognitive levels. Teachers' proficiency in both content knowledge and instructional technology is therefore paramount to maximizing the benefits of learning media in mathematics education (Boris et al., 2013).

In recent years, programming environments like Scratch have emerged as promising platforms for educational innovation. Scratch is a visual programming language designed to introduce coding concepts through block-based interfaces, making it accessible to young learners without prior programming experience (Zamin et al.,2018). Beyond teaching computational thinking, Scratch offers rich opportunities to integrate subject matter learning with interactive and creative activities. Studies have demonstrated that Scratch can effectively support mathematics learning by enabling students to create digital artifacts that embody mathematical concepts, thereby deepening their understanding through active construction and exploration (Calder, 2018).

For example, Calder's research with 10-year-old students revealed that using Scratch to develop mathematical games and simulations not only enhanced problem-solving skills but also encouraged reflective learning practices such as blogging about their coding process. This approach fosters metacognition and a deeper engagement with mathematical ideas (Calder, 2018). Similarly, Fagerlund et al. (2021) conducted a systematic review highlighting Scratch's capacity to cultivate computational thinking within primary education curricula across multiple countries. Their findings emphasize Scratch's multidimensional content and activities, which support diverse learning objectives including creativity, collaboration, and critical thinking (Fagerlund et al., 2021).

Despite these promising developments, there remains a notable gap in the application of Scratch-based learning media specifically tailored to elementary geometry education, particularly in contexts that also aim to integrate character education. While Scratch's potential for fostering computational and mathematical skills is well-documented, its use as a medium to simultaneously promote values education—such as the Pancasila values central to Indonesian education—has been underexplored. This gap presents an opportunity to innovate by designing learning media that not only improve cognitive outcomes but also nurture students' moral and social development through gamified, interactive experiences.

The present study seeks to address this gap by developing a programming-based learning media using Scratch, focused on Grade IV Geometry material, and embedding character education elements aligned with Pancasila values. The research aims to evaluate the validity and effectiveness of this media in enhancing students' understanding of geometric concepts and their internalization of character values through gamification and case study-based questions. By employing a rigorous Research and Development (R&D) methodology grounded in the ADDIE model, this study systematically designs, implements, and assesses the learning media, ensuring alignment between the pedagogical framework, technological features, and educational outcomes.

In doing so, this research contributes to the advancement of educational technology in elementary mathematics, offering empirical evidence on the benefits of integrating programming-based media with character education. It also provides practical insights for educators and curriculum developers seeking to leverage Scratch as a versatile tool for holistic student development. Ultimately, this study aspires to enrich the learning experiences of young students, making mathematics more accessible, engaging, and meaningful, while fostering the values essential for their growth as responsible and thoughtful citizens.

2. Literature Review

The integration of programming-based learning media into elementary education has garnered increasing attention as educators seek innovative methods to enhance student engagement and comprehension, particularly in mathematics. Programming environments like Scratch have emerged as powerful tools that facilitate active learning by enabling students to create, manipulate, and interact with digital content, thereby fostering deeper conceptual understanding and computational thinking skills. This literature review critically examines existing research on programming-based learning media, the application of Scratch in educational contexts, the role of gamification in learning, and the incorporation of character education, with a focus on their relevance to the current study on Geometry education for Grade IV students.

Programming-based learning media leverage the principles of constructivist learning theory, which posits that learners construct knowledge actively through experience and reflection rather than passively receiving information. By

engaging students in programming tasks, such media encourage exploration, problem-solving, and creativity, which are essential for mastering complex subjects like mathematics. Research by Korkmaz (2016) demonstrated that Scratch-based game activities significantly improved students' attitudes, self-efficacy, and academic achievement in mathematics, highlighting the motivational benefits of interactive programming environments. Similarly, Husna et al. (2019) found that project-based learning models aided by Scratch media enhanced both learning outcomes and creativity among elementary students, underscoring the dual cognitive and affective advantages of such approaches (Korkmaz, 2016; Husna et al., 2019).

Scratch, developed by the MIT Media Lab, is particularly well-suited for young learners due to its block-based, visual programming interface that reduces syntactic complexity and allows focus on logical sequencing and problem-solving. Its widespread adoption in primary education is supported by extensive literature documenting its effectiveness in fostering computational thinking, creativity, and collaboration. Fagerlund et al. (2021) conducted a systematic review of Scratch programming in K-9 education across Finland, England, and Estonia, concluding that Scratch's multidimensional content and activities holistically support computational thinking development and can be effectively assessed within diverse curricula. Their study emphasized Scratch's adaptability and its capacity to engage students in meaningful learning experiences that transcend traditional rote memorization (Fagerlund et al., 2021).

In the context of mathematics education, Scratch has been employed to create interactive learning objects that concretize abstract concepts. Calder (2018) investigated the use of Scratch for coding mathematical ideas among 10-year-old students, revealing that students who designed digital games and simulations exhibited enhanced problem-solving abilities and a more profound understanding of mathematical principles. The study also highlighted the value of reflective practices, such as blogging about coding progress, in reinforcing learning and metacognitive skills (Calder, 2018). These findings align with Etyarisky, and Marsigit (2022) cognitive theory of multimedia learning, which advocates for the use of interactive, multimodal instructional materials to improve comprehension and retention (Etyarisky & Marsigit, 2022).

Gamification—the application of game design elements in non-game contexts—has been widely recognized as an effective strategy to increase learner motivation, engagement, and persistence. In educational settings, gamification can transform learning activities into enjoyable and rewarding experiences, thereby reducing anxiety and resistance often associated with challenging subjects like mathematics. Zainuddin et al. (2020) demonstrated that gamification elements such as quizzes, challenges, and immediate feedback significantly enhanced student motivation and interaction in learning environments. Their research supports the integration of gamified features within programming-based media to create dynamic and student-centered learning experiences (Zainuddin et al., 2020).

Character education, which focuses on developing students' moral and ethical values alongside academic skills, is increasingly being integrated into technology-enhanced learning. The Indonesian educational framework emphasizes Pancasila values—principles that promote unity, democracy, social justice, and cultural respect—as foundational to student development. However, the literature reveals a paucity of studies that explicitly combine character education with programming-based learning media in elementary mathematics. Gregg (2014) identified the underutilization of Scratch in supporting character education, particularly in the context of elementary schools, and advocated for the development of interactive media that embed these values within engaging learning activities (Gregg, 2014).

The current study builds upon this gap by designing Scratch-assisted learning media that not only facilitate the acquisition of Geometry knowledge but also integrate Pancasila values through gamification and case study-based questions. This dual focus aligns with contemporary educational paradigms that emphasize holistic student development, combining cognitive, social, and emotional learning domains. Noting that technology integration in education can simultaneously improve academic quality and foster a positive, value-driven learning atmosphere.

Moreover, the literature underscores the importance of aligning learning media design with students' developmental stages and cognitive abilities. Krajcik & Czerniak (2018) highlighted that elementary students, particularly those aged 7 to 12, require creative and varied instructional methods to sustain interest and facilitate understanding. Conventional teaching methods often fail to engage this age group effectively, leading to boredom and misconceptions. The interactive and visually rich nature of Scratch-based media addresses these challenges by providing age-appropriate, scaffolded learning experiences that promote active participation and conceptual clarity (Krajcik & Czerniak, 2018).

In summary, the reviewed literature establishes a strong theoretical and empirical foundation for the development of programming-based learning media using Scratch in elementary mathematics education. It highlights Scratch's proven efficacy in enhancing computational thinking and mathematical understanding, the motivational benefits of gamification, and the emerging need to integrate character education within technology-enhanced learning environments. However, it also reveals a critical gap in the application of such integrated media specifically targeting Geometry education and character development in Grade IV students. This study addresses this gap by creating and validating a Scratch-assisted learning media that aligns with curricular goals, developmental appropriateness, and holistic educational objectives, thereby contributing novel insights and practical solutions to the field of educational technology and mathematics pedagogy.

3. Methodology

This study employed a Research and Development (R&D) approach, utilizing the ADDIE model as the guiding framework for the systematic creation, implementation, and evaluation of the programming-based learning media. The ADDIE model, an acronym for Analysis, Design, Development, Implementation, and Evaluation, is widely recognized for its structured and iterative process in instructional design, ensuring that educational interventions are both pedagogically sound and contextually relevant (Branch & Varank, 2009). Each phase of the ADDIE model was meticulously executed to align the learning media with the educational needs of Grade IV elementary students, particularly focusing on Geometry material and the integration of Pancasila values through gamification elements.

3.1 Analysis Phase

The initial phase involved a comprehensive needs assessment to identify the specific learning challenges faced by fourth-grade students in understanding Geometry concepts and to ascertain the requirements of teachers regarding instructional media. Data collection methods included structured interviews and surveys administered to both students and educators within the target schools. These instruments aimed to capture qualitative and quantitative insights into students' difficulties, motivational levels, and preferences for learning tools, as well as teachers' perspectives on curriculum demands and technological readiness.

The analysis revealed a significant gap in interactive and engaging learning resources tailored to the cognitive and developmental levels of Grade IV students. Teachers reported limited availability of media that effectively combine mathematical content with character education, particularly the Pancasila values central to the Indonesian curriculum. Students expressed challenges in grasping abstract geometric concepts and a preference for learning activities that incorporate play and immediate feedback. These findings provided a critical foundation for the subsequent design and development stages, ensuring that the learning media would be responsive to actual classroom needs and conducive to enhancing both cognitive and affective learning outcomes (Clark & Mayer, 2023).

3.2 Design Phase

Guided by the insights from the analysis phase, the design phase focused on conceptualizing the structure, content, and user interface of the Scratch-assisted learning media. The design incorporated educational theories related to multimedia learning and gamification, ensuring that the media would be both pedagogically effective and engaging. The media was structured into progressive levels—initial display, first through fourth levels—each corresponding to increasing complexity in Geometry topics aligned with the Grade IV curriculum.

Key design elements included the integration of Pancasila values through contextualized case study questions and gamified features such as quizzes, challenges, and an automatic scoring system. Visual and auditory stimuli were carefully selected to appeal to young learners, with attention to color schemes, character representations, and navigation simplicity to facilitate ease of use. The design also emphasized clear instructions and feedback mechanisms to support self-paced learning and reinforce conceptual understanding. This phase involved iterative consultations with educational experts to validate the appropriateness of content, design aesthetics, and alignment with learning objectives (Santos & Boticario, 2015).

3.3 Development Phase

In the development phase, the conceptual designs were translated into a functional learning media prototype using the Scratch application. All instructional materials, including geometric problems, Pancasila value scenarios, and gamification components, were programmed and integrated within the Scratch environment. The development process involved meticulous coding of interactive elements, animation sequences, and automatic assessment features to ensure seamless user experience and accurate performance tracking. The development team conducted internal testing to identify and rectify technical issues, optimize interface responsiveness, and enhance the clarity of instructional content. This phase also included the preparation of supporting documentation and user guides for teachers and students to facilitate effective implementation. The iterative nature of the ADDIE model allowed for continuous refinement based on feedback from pilot users and experts, ensuring that the final product was robust, user-friendly, and pedagogically sound.

3.4 Implementation Phase

The implementation phase involved deploying the developed learning media in real classroom settings with fourth-grade students. A purposive sample of students from selected elementary schools participated in the media trial. Prior to the intervention, students completed a pre-test designed to assess their baseline understanding of Geometry concepts and familiarity with Pancasila values. The learning media was then introduced and used over a predetermined instructional period, during which students engaged with the Scratch-based activities under teacher supervision. Teachers facilitated the sessions, providing guidance as needed while encouraging independent exploration of the media. Observations were conducted to monitor student engagement, interaction patterns, and any technical or instructional challenges encountered.

The implementation was designed to mirror authentic classroom conditions to ensure ecological validity and to gather realistic data on the media's usability and effectiveness (Carter et al., 2008)

3.5 Evaluation Phase

The evaluation phase comprised both formative and summative assessments to measure the learning media's impact on student outcomes and to validate its overall effectiveness. Quantitative data were collected through post-tests administered immediately after the intervention, mirroring the pre-test format to enable direct comparison of student performance. The pre-test and post-test scores were statistically analyzed using paired sample t-tests to determine the significance of learning gains attributable to the Scratch-assisted media. In addition to student assessments, qualitative data were gathered through expert interviews involving three specialists in mathematics education, instructional design, and educational technology. These experts evaluated the media's content validity, design quality, and pedagogical effectiveness based on structured questionnaires covering aspects such as appropriateness of mathematical material, clarity of instructions, engagement potential, and alignment with character education goals. The evaluation also incorporated feedback on navigational design, interface aesthetics, and suggestions for improvement, providing a comprehensive understanding of the media's strengths and areas for enhancement. This multi-faceted evaluation approach ensured that the findings were robust, triangulated, and directly linked to the methodological rigor established in earlier phases (Copestake, 2014).

3.6 Data Collection Methods

Data collection was integral to each phase of the ADDIE model, employing a mixed-methods approach to capture both quantitative and qualitative dimensions of the study. Needs surveys and interviews during the analysis phase provided foundational insights into learner and teacher requirements. During implementation, pre-tests and post-tests quantitatively measured student learning outcomes, while classroom observations documented engagement and interaction dynamics. Expert interviews conducted during the evaluation phase offered qualitative validation and critical appraisal of the learning media. The combination of these data sources facilitated a comprehensive assessment of the media's effectiveness, usability, and educational value, ensuring that the research findings were well-supported and actionable.

The primary statistical technique employed to evaluate the effectiveness of the Scratch-assisted learning media was the paired sample t-test. This inferential statistical method is appropriate for comparing the means of two related groups—in this case, students' pre-test and post-test scores—to determine whether the intervention produced a statistically significant improvement in learning outcomes (Panuluh, 2022). The paired sample t-test was conducted under the assumptions of normality and independence of observations, with effect sizes calculated to quantify the magnitude of learning gains. The statistical analysis was complemented by descriptive statistics, including means, standard deviations, and percentage improvements, to provide a detailed portrayal of student performance changes. This rigorous analytical approach ensured that the conclusions drawn regarding the media's impact on Geometry understanding and character education were empirically substantiated and aligned with the study's research questions and objectives.

Through the meticulous application of the ADDIE model, comprehensive data collection, and robust statistical analysis, this methodology section establishes a clear and coherent foundation for the subsequent presentation of results and discussion. The alignment between methodological rigor and research aims ensures that the findings are credible, meaningful, and directly relevant to advancing programming-based learning media in elementary mathematics education.

4. Results

The implementation and evaluation of the Scratch-assisted programming-based learning media yielded compelling evidence of its effectiveness in enhancing fourth-grade students' understanding of Geometry concepts and their internalization of Pancasila values. This section presents a detailed account of the findings from the media trials, statistical analyses of learning outcomes, and observations related to student engagement and motivation. The results are organized to directly reflect the methodological framework, ensuring a clear linkage between the intervention design and its educational impact. The learning media was trialed with a cohort of 60 fourth-grade students from two elementary schools, selected to represent typical classroom demographics. Prior to the intervention, students completed a pre-test assessing their baseline knowledge of Geometry topics aligned with the Grade IV curriculum, including basic shapes, properties, and spatial reasoning. Following a two-week instructional period using the Scratch-based media, students undertook a post-test designed to measure gains in the same content areas.

Qualitative observations during the trial indicated high levels of student engagement. The gamified elements—such as quizzes, challenges, and immediate feedback—were particularly effective in sustaining interest and encouraging repeated attempts to master the material. Students demonstrated enthusiasm in navigating the Scratch interface, often collaborating informally to solve problems and share strategies. Teachers reported that the media's visual and interactive features helped clarify abstract geometric concepts, making learning more accessible and enjoyable. Furthermore, the integration of Pancasila values through contextualized case studies resonated with students, who were able to relate these moral principles to the scenarios presented in the media. This dual focus on cognitive and character education was noted as a distinctive strength by both educators and students, fostering a holistic learning environment. The quantitative

evaluation of learning outcomes employed paired sample t-tests to compare pre-test and post-test scores, providing a rigorous measure of the media's impact on student understanding. Table 1 summarizes the descriptive statistics and inferential test results.

Table 1. Pre and post-test scores on geometry understanding

Test	Mean Score	Standard Deviation	t-value	p-value	Effect Size (Cohen's d)
Pre-test	58.3	12.4			
Post-test	81.7	10.2	12.56	<0.001	1.62

The analysis revealed a statistically significant increase in students' Geometry test scores following the intervention ($t(59) = 12.56$, $p < 0.001$), with a large effect size (Cohen's $d = 1.62$), indicating a substantial improvement in learning outcomes. This result confirms that the Scratch-assisted programming-based learning media effectively enhanced students' comprehension of geometric concepts. In addition to content knowledge, students' understanding of Pancasila values was assessed through embedded case study questions within the media. Analysis of these responses showed a marked improvement in students' ability to identify and apply character values in relevant contexts, further supporting the media's dual educational objectives.

Beyond cognitive gains, the study closely monitored affective outcomes, particularly student motivation and engagement, which are critical for sustained learning success. Classroom observations and teacher reports highlighted several key indicators of positive engagement. Students demonstrated active participation by consistently interacting with the media, completing levels and challenges with enthusiasm. The immediate feedback and scoring system effectively motivated them to improve their performance and persist through difficulties. The design of the media also encouraged collaborative learning, fostering peer discussion and cooperative problem-solving. This led to the development of a supportive learning community where students shared tips on navigating Scratch and discussed geometric concepts, thereby enhancing social learning dynamics. Furthermore, post-intervention surveys revealed a significant shift in students' attitudes toward mathematics, with many expressions expressing increased enjoyment and confidence in learning Geometry. This positive change is largely attributed to the interactive and gamified approach of the media, which transformed mathematics from a traditionally daunting subject into an engaging and enjoyable experience. Additionally, the integration of Pancasila values through relatable scenarios and challenges promoted reflection and discussion on ethical behavior, social responsibility, and cultural respect. Teachers observed that students began to demonstrate greater awareness and application of these values in their classroom interactions.

Expert evaluations of the media's design elements corroborated the positive student experiences. The use of vibrant colors, clear text, and intuitive navigation was praised for its appropriateness to the developmental level of Grade IV students. The leveling structure, progressing from simple to more complex tasks, was effective in scaffolding learning and maintaining motivation. Suggestions for improvement included enhancing storyline clarity and incorporating more illustrative images to support comprehension, which will inform future iterations of the media. The results unequivocally demonstrate that the Scratch-assisted programming-based learning media is an effective educational tool for improving fourth-grade students' understanding of Geometry and fostering character education aligned with Pancasila values. The significant gains in test scores, coupled with high levels of engagement and positive attitudinal shifts, underscore the media's potential to transform elementary mathematics education. These findings validate the methodological rigor of the ADDIE-based development process and provide a strong empirical foundation for the broader application and further refinement of programming-based learning media in diverse educational settings.

5. Discussion

The findings of this study provide compelling evidence that programming-based learning media developed with the Scratch application can significantly enhance fourth-grade students' understanding of Geometry concepts while simultaneously fostering character education aligned with Pancasila values. This discussion interprets these results in the context of existing literature, elaborates on the role of gamification and Scratch-based media in motivating learners, and explores the educational implications of integrating character education within technology-enhanced learning environments. Additionally, expert feedback and suggestions for improvement are examined to provide a comprehensive understanding of the media's strengths and areas for future development.

The statistically significant improvement in students' Geometry comprehension, as demonstrated by the paired sample t-test results, aligns with prior research highlighting the efficacy of Scratch as a tool for mathematics education. Calder (2018) emphasized that Scratch enables students to engage actively with mathematical ideas through the creation of digital learning objects, which deepens conceptual understanding and problem-solving skills. Similarly, Fagerlund et al. (2021) underscored Scratch's capacity to develop computational thinking and support multidimensional learning activities that foster creativity and critical thinking. The current study extends these findings by demonstrating that Scratch's visual programming environment can be effectively tailored to elementary Geometry content, providing scaffolded learning experiences that accommodate the cognitive development of Grade IV students. The progressive

leveling structure and interactive features facilitated incremental mastery of geometric concepts, which is consistent with the cognitive theory of multimedia learning advocating for well-designed, interactive instructional materials to enhance comprehension and retention.

Beyond cognitive gains, the integration of gamification elements within the learning media played a pivotal role in increasing student motivation and engagement. Gamification strategies such as quizzes, challenges, immediate feedback, and automatic scoring transformed the learning process into an enjoyable and rewarding experience. This aligns with findings that gamification enhances learner motivation by making educational activities more interactive and fun, thereby reducing anxiety and resistance often associated with mathematics. The observed high levels of active participation, persistence, and positive attitudes toward Geometry in this study corroborate these assertions. The gamified environment encouraged students to take ownership of their learning, engage in repeated practice, and collaborate with peers, fostering a dynamic and supportive classroom culture. These affective outcomes are critical, as motivation and engagement are well-established predictors of academic success and long-term learning persistence.

A distinctive and innovative aspect of this study is the deliberate integration of character education through the embedding of Pancasila values within the Scratch-based learning media. While previous research has extensively documented Scratch's role in developing computational and mathematical skills, its application as a medium for values education remains underexplored. The current findings demonstrate that incorporating case study-based questions and scenarios reflecting Pancasila principles effectively supported students' moral and social development alongside cognitive learning. This dual focus addresses a significant gap in the limited utilization of Scratch in promoting character education in elementary schools. The positive feedback from both students and teachers regarding the relevance and clarity of these value-based components suggests that technology-enhanced learning media can serve as powerful platforms for holistic education, nurturing not only intellectual growth but also ethical awareness and social responsibility. Expert evaluations further validated the media's design and pedagogical effectiveness, affirming that the visual elements, navigation, and instructional clarity were well-suited to the developmental needs of elementary students. The experts' recommendations to strengthen the storyline and incorporate more illustrative images provide valuable guidance for enhancing the media's instructional design. These suggestions resonate with the emphasis on the importance of coherent narratives and multimodal support in multimedia learning to facilitate deeper understanding. Addressing these recommendations in future iterations will likely improve user experience and learning outcomes, ensuring the media remains engaging and accessible.

The alignment between the methodology and results is evident throughout the study. The systematic application of the ADDIE model ensured that the learning media was grounded in a thorough needs analysis, carefully designed to meet curricular and developmental requirements, and rigorously evaluated through empirical data collection and expert review. This methodological rigor strengthens the validity of the findings and supports the conclusion that Scratch-assisted programming-based learning media is an effective and innovative approach to elementary Geometry education. The use of pre-test and post-test assessments, combined with qualitative observations and expert feedback, provided a comprehensive evaluation framework that captured both cognitive and affective dimensions of learning.

Educationally, the implications of this study are multifaceted. First, it demonstrates that integrating programming and gamification into mathematics instruction can transform traditionally challenging subjects into engaging and meaningful learning experiences. This has the potential to shift pedagogical paradigms in elementary education, encouraging educators to adopt technology-enhanced, student-centered approaches that foster active learning and motivation. Second, the successful embedding of character education within the learning media highlights the feasibility and importance of holistic education models that address cognitive, social, and moral development simultaneously. This is particularly relevant in contexts like Indonesia, where Pancasila values are foundational to national education goals. Third, the study provides a replicable framework for developing and evaluating similar programming-based learning media across other subjects and age groups, promoting scalability and adaptability in educational technology innovation.

5. Conclusion

In conclusion, the discussion underscores that the Scratch-assisted programming-based learning media developed in this study not only improves students' understanding of Geometry but also enriches their character education through gamified, interactive experiences. The positive outcomes in motivation, engagement, and values internalization affirm the media's potential as a comprehensive educational tool. Future research and development should build upon these findings by refining the media's design based on expert feedback, expanding its application to diverse learning contexts, and exploring long-term impacts on student learning trajectories and character formation. This study thus contributes significantly to the evolving landscape of technology-enhanced education, offering practical insights and evidence-based strategies for advancing elementary mathematics instruction and holistic student development.

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Conflict of Interest

The authors declare no conflicts of interest.

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