Developing Interactive Multimedia for Informatics Learning to Support Quality Education (SDG 4)

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Abstract: The rapid development of digital technology requires learning approaches that integrate interactive media to enhance student engagement and conceptual understanding. However, Informatics learning in many senior high schools is still dominated by teacher-centered instruction, which limits students' opportunities to explore concepts actively. Therefore, innovative digital learning media are needed to support more interactive and student-centered learning environments. This study aims to develop and evaluate interactive multimedia for learning basic computer operations and software functions in Grade 10 Informatics. The research employed a Research and Development (R&D) approach using the Instructional Development Institute (IDI) model, which applies a systematic instructional design through three stages: define, develop, and evaluate. The study involved 30 tenth-grade students and two Informatics teachers at SMA Negeri 2 Bukittinggi, Indonesia. Data were collected through expert validation sheets, teacher and student response questionnaires, and learning outcome tests using a one-group pretest–posttest design. The results show that the multimedia achieved very high validity (4.62) and excellent practicality (90.6%). The effectiveness test produced an N-gain score of 0.60, indicating a moderate level of effectiveness. These findings suggest that the multimedia is valid, practical, and moderately effective for supporting digital learning aligned with Sustainable Development Goal 4 (Quality Education).

Keywords: Informatics education; Instructional design model; Interactive multimedia; Learning effectiveness; Sustainable quality education

Introduction

The development of digital technology has shifted the learning paradigm from conventional models to interactive technology-based learning systems (Sitorus et al., 2025). In the era of 21st-century educational transformation, educators' ability to utilize technology in the teaching and learning process is a primary requirement to improve the quality of learning outcomes (Kalyani, 2024). Improving the quality of digital learning environments is also closely related to the achievement of Sustainable Development Goal 4 (SDG 4), which emphasizes inclusive and equitable quality education and the promotion of lifelong learning opportunities for all (Islam & Khan, 2024). In this context, interactive multimedia plays a crucial role as a tool capable of combining text, images, sound, animation, and video into a dynamic, engaging medium for students (Mayer, 2021).

An effective learning process requires not only informative delivery of material but also interactive and meaningful delivery (Widiasanti et al., 2023). According to the Cognitive Theory of Multimedia Learning (Festiyed et al., 2023), learning will be more optimal if students gain learning experiences through a balanced integration of visual and auditory elements. Interactive

multimedia is one implementation of this theory, as it allows students to interact directly with learning content, explore material at their own pace, and obtain feedback independently (McClure & Williams, 2021).

In Indonesia, the integration of interactive multimedia into learning has grown rapidly, emphasizing independence and flexibility in learning. However, learning practices in senior high schools (SMA) still exhibit conventional tendencies, with teachers being the primary source of information and students being passive (Agustina et al., 2023). This situation has the potential to reduce students' interest and motivation in learning, particularly in Informatics, which is highly relevant to the digital world (Nurhasanah et al., 2025).

Previous research has shown that the use of interactive multimedia can significantly improve student motivation, conceptual understanding, and learning outcomes compared to traditional lecture methods (Bahrudin & Yogihati, 2022; Hadi et al., 2022). Furthermore, interactive media also allows students to learn independently outside of class, increases cognitive engagement, and accommodates diverse learning styles (Arifin et al., 2021; Hadi et al., 2022).

However, the success of interactive multimedia implementation is determined not only by its availability but also by the validity of the instructional design and its suitability to student needs (Adhana & Andriani, 2024). Therefore, developing interactive multimedia-based learning media requires a systematic approach that considers aspects of validity, practicality, and effectiveness, as outlined in the Instructional Development Institute (IDI) development model (Adhana & Andriani, 2024; Riaddin & Umasugi, 2021).

Based on this context, this research focuses on the development and testing of interactive multimedia as a learning medium to improve student learning outcomes in Informatics in grade 10 of high school. This development is expected to not only contribute to improving the quality of classroom learning but also serve as an innovative model for implementing learning technology at the secondary level. Furthermore, this research is intended to support the improvement of digital learning quality in line with the objectives of Sustainable Development Goal 4 (Quality Education), which emphasizes inclusive and equitable quality education through the integration of educational technology (Gunawan, 2025).

Method

Research Design

This research employed a Research and Development (R&D) approach with the Instructional Development Institute (IDI) model, modified to suit the needs of technology-based learning research (Sania et al., 2022; Tampubolon et al., 2022). The IDI model was chosen because it emphasizes a systematic development process oriented toward improving the quality of learning products through three main stages: define (needs analysis), develop (development and validation), and evaluate (practicality and effectiveness testing (Dousay & Branch, 2023).

The R&D approach was deemed most appropriate because the research objective was not merely to obtain empirical data but also to produce an educational product in the form of valid, practical, and effective interactive multimedia to support the Informatics learning process at the high school level (Tsaniyyati & Andriani, 2024). The flowchart of this research procedure is as follows.
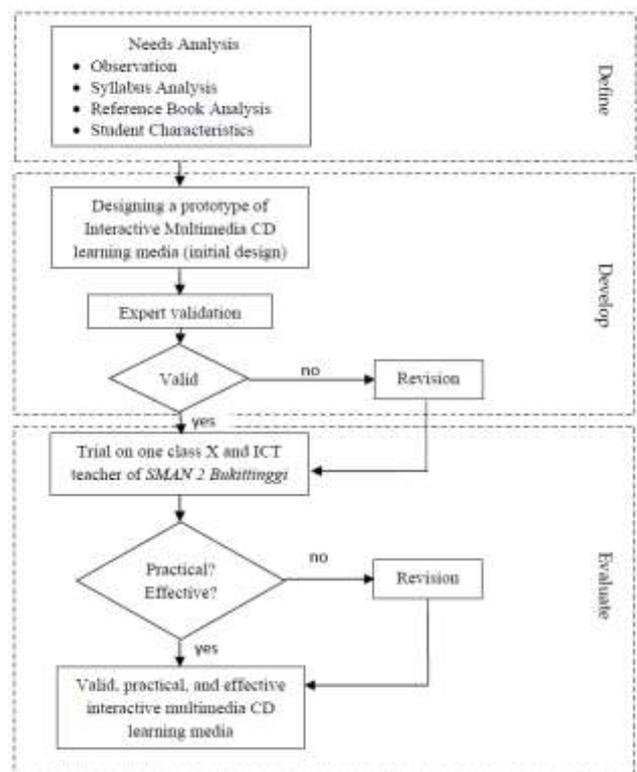
Figure 1. Flowchart of research procedures

Define Stage

This stage aimed to identify learning needs and challenges faced by students in understanding Informatics materials. The activities included analyzing learning needs through classroom observations and interviews with teachers to understand the current learning practices (Lukman et al., 2023). In addition, student characteristics were examined to identify their learning styles, levels of digital literacy, and preferences for learning media (Essa et al., 2023; Lwande et al., 2021). A material analysis was also conducted by reviewing the

Merdeka Belajar curriculum and the basic ICT competencies established by the Ministry of Education, Culture, Research, and Technology (Muflihin & Warsito, 2024). The analysis results indicate that learning is still predominantly teacher centered, and conventional teaching media have not been able to increase active student engagement. This situation reinforces the urgency of developing interactive multimedia-based media (Tuhuteru et al., 2023).

Develop Stage

This stage involved the design, validation, and revision of the interactive multimedia product. The initial product design was developed as a prototype using Macromedia Flash and Camtasia Studio with an exploratory tutorial based structure that allowed students to learn independently and interactively (Mavrikis et al., 2022). The content was developed based on the Grade 10 Informatics syllabus for the first semester and integrated various multimedia elements, including text, images, animations, audio, and short instructional videos.

After the prototype was developed, expert validation was conducted to evaluate the quality of the multimedia. The validation process involved two subject matter experts, who were Informatics teachers, and two media experts, who were lecturers in Informatics education. The validation instrument referred to criteria related to the appropriateness of content, language clarity, presentation structure, interactivity, and visual appearance (Indarta et al., 2023).The validation results were analyzed using a five-point Likert scale. The multimedia product was considered valid when the average validation score was equal to or greater than 3.5 (Arif et al., 2023).

Following the validation process, revisions were made based on suggestions and feedback provided by the experts. These revisions aimed to improve both the instructional and technical aspects of the multimedia until a final version of the product was obtained and ready to be tested for practicality and effectiveness.

Evaluate Stage

This stage aimed to assess the practicality and effectiveness of the developed multimedia through limited classroom trials. The practicality test was conducted using questionnaires completed by teachers and students to evaluate several aspects, including ease of use, clarity of navigation, time efficiency, and students' learning interest (Ananda & Usmeldi, 2023; Darma et al., 2021). The practicality level of the multimedia was determined based on the percentage of questionnaire scores, where a score of 80% or higher indicated a high level of practicality.

The effectiveness of the multimedia was evaluated using a one-group pretest–posttest design to measure improvements in students' learning outcomes. Data were collected through cognitive learning outcome tests administered before and after the learning activities, as well as observations of student participation during the learning process. The media was considered effective when there was an increase of more than 20% in the average score between the pretest and posttest results.

Research Instruments

The instruments used in this study included: expert validation sheets (materials and media), teacher and student response questionnaires, and student learning outcome tests (consisting of objective questions based on core competency indicators). Each instrument was developed with consideration for the principles of content validity, internal reliability, and appropriateness for its context.

Data Analysis Techniques

Quantitative data were analyzed descriptively using averages, percentages, and N-gain to measure learning outcomes. The N-gain formula is:

$$N_{gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximal Score} - \text{Pretest Score}} \qquad (1)$$

Category interpretation: high (> 0.7), moderate (0.3–0.7), low (< 0.3). Qualitative data from interviews and validator comments were analyzed using data reduction and thematic interpretation techniques to strengthen the quantitative results.

Result and Discussion

This study produced an interactive multimedia product for Grade 10 Informatics learning, specifically focusing on basic computer operations and software functions. The development process followed the three stages of the Instructional Development Institute (IDI) model: define, develop, and evaluate.

Define Stage

A needs analysis shows that Informatics learning at SMA Negeri 2 Bukittinggi is still dominated by conventional lecture and practice methods. Observations of 30 students revealed that 70% reported monotonous learning, and 63% struggled to understand practical computer material, particularly on the topics of "basic computer operations" and "software functions." Interviews with teachers revealed the limitations of interactive visual media as the primary cause of low student engagement. Therefore, media that enable students to learn independently, actively, and

exploratively are needed (Rosbina et al., 2025; Wiwin et al., 2022).

Develop Stage
Expert Validation

Validation was conducted by two material experts and two media experts using a 1–5 Likert scale (1 = not valid, 5 = very valid). Aspects assessed included content, learning design, graphical display, interactivity, and language.

Table 1. Validation results

Validation Aspects	Average Score	Category
Suitability of material with basic competencies	4.80	Very valid
Display quality and navigation	4.60	Very valid
Clarity of language and narrative	4.40	Valid
Multimedia integration (audio, animation, interactivity)	4.70	Very valid
Conformity of learning theory and instructional flow	4.60	Very valid
Overall average	4.62	Very valid

Validator comments emphasized the media's strengths in visualizing abstract concepts, but suggested the addition of interactive simulations for hardware connectivity topics. Revisions were made based on expert advice prior to field testing. These results meet the content and design validity criteria required by Arif et al. (2023), which state that a medium is considered suitable for use if its validation score is ≥ 3.5.

Practicality Test

The practicality test involved two ICT teachers and 30 students. Aspects observed included ease of use, time efficiency, attractive appearance, and usefulness in understanding the material.

Table 2. Practicality results

Practicality Aspect	Teacher Score (%)	Student Score (%)	Average (%)	Category
Ease of navigation and use	92.5	89.8	91.1	Very practical
Readability of text and narrative	88	90.2	89.1	Practical
Interest in display and animation	94	95.6	94.8	Very practical
Efficiency of study time	85	86.4	85.7	Practical
Benefits for understanding the material	93.5	91.3	92.4	Very practical
Overall average	-	-	90.6	Very practical

The questionnaire results showed that the media was easy to use and visually appealing, and helped students understand the practical steps of computer use. Teachers assessed that this multimedia accelerated the learning process, saving approximately 30% of their time compared to conventional methods. This finding aligns with Bansah & Agyei (2022), who asserted that learning media is considered practical if it scores above 80% on the aspects of ease and efficiency of use.

Effectiveness Test

Effectiveness was measured using a one-group pretest–posttest design on 30 students. The test consisted of 20 multiple-choice questions assessing understanding of basic informatics concepts.

Table 3. Effectiveness results

Test Stages	Average Score	Completion Percentage (%)	Category
Pretest	63.2	46.7	Low
Posttest	85.4	90	High
N-gain	0.60	-	Medium–High

A score increase of 22.2 points with an N-gain of 0.60 demonstrates the media's effectiveness in improving learning outcomes (Fadhilah & Mulyani, 2024; Rosdiana & Ulya, 2021). In addition to cognitive enhancement, observations show an increase in student learning activity from 46.7 to 90%, particularly in the categories of actively asking questions and attempting independent simulations. These results support the findings of Bahrudin & Yogihati (2022) and Sartono et al. (2022) that interactive multimedia designed cognitive theory of multimedia can significantly improve conceptual understanding and learning motivation.

Discussion

Media validity demonstrates that the applied instructional design aligns with the principles of cognitive multimedia learning (Moore, 2006) and the IDI model, which emphasizes alignment between needs analysis and content design (Dousay & Branch, 2023). The integration of text, audio, animation, and interactivity enhances message clarity and supports students' visual-auditory learning (Mansour, 2025). This reinforces Han (2024) view that conceptual clarity in multimedia depends on the balance between visualization and user cognitive load.

The very high level of practicality (90.6%) indicates that the media is easy to use for both teachers and students. The exploratory tutorial-based navigation feature allows for independent learning without losing direction, while the visual design, based on soft contrasting colors, enhances learning focus. Teachers reported that this media reduces lecture dominance and encourages student participation. These results align with the findings of Wang & Zhang (2022), who

emphasized that exploration-based design can enhance learner autonomy and self-directed learning.

The increase in learning outcomes with an N-gain of 0.60 and an increase in mastery level to 90% indicate a positive improvement in students' basic Informatics competencies after using the developed multimedia. The N-gain value falls within the moderate category, suggesting that the use of interactive multimedia is associated with improved students' conceptual understanding of the learning material. These results reinforce the findings of Lu & Hanim (2024), who reported that interactivity and multimodality in digital media can enhance learning engagement and knowledge retention. Observational findings during the learning process also indicated higher student participation and curiosity when interacting with the multimedia content. Overall, the developed interactive multimedia demonstrates high validity and practicality and shows promising potential to support Informatics learning at the high school level. Furthermore, the development of interactive multimedia that supports active and independent learning also contributes to broader educational goals, particularly the implementation of Sustainable Development Goal 4 (Quality Education), which emphasizes the importance of technology integration to improve learning quality and accessibility (Bhaduri et al., 2025).

Conclusion

This study developed interactive multimedia for Grade 10 Informatics learning focusing on basic computer operations and software functions using the Instructional Development Institute (IDI) development model. The validation results indicate that the developed multimedia achieved a very high level of validity with an average score of 4.62, suggesting that the content, instructional design, and visual presentation are appropriate for learning purposes. The practicality test results, with an average score of 90.6%, show that the multimedia is easy to use and well accepted by both teachers and students during classroom implementation. The improvement in students' cognitive learning outcomes, indicated by an N-gain value of 0.60 in the medium category, demonstrates a positive increase in students' understanding after using the developed multimedia. Although the study used a one-group pretest–posttest design, the results suggest that the multimedia shows promising potential to support Informatics learning. Overall, the developed multimedia demonstrates high validity and practicality and is associated with improved student learning outcomes in basic Informatics concepts.

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