JKTP: Jurnal Kajian Teknologi Pendidikan
Vol. 8, No. 4, November 2025: 270-283
e-ISSN: 2615-8787
DOI: 10.17977/um038v8i42025p270-283
https://journal-fip.um.ac.id/index.php/jktp

DEVELOPMENT OF INTERACTIVE MULTIMEDIA WITH A DIFFERENTIATED APPROACH TO THE MATERIAL OF SEQUENCING ALGORITHMS FOR HIGH SCHOOL STUDENTS

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Article History
Received: 02 September 2025, Accepted: 23 October 2025, ***Published: 15 November 2025***

Abstrak
Materi algoritma pengurutan merupakan bagian dari pembelajaran informatika memiliki karakteristik abstrak yang menyebabkan siswa kesulitan memahami konsep dan logika prosesnya. Permasalahan ini semakin kompleks akibat penggunaan media pembelajaran yang tidak interaktif dan belum mengakomodasi perbedaan gaya belajar siswa. Oleh karena itu, penelitian ini bertujuan mengembangkan multimedia interaktif dengan pendekatan berdiferensiasi untuk memfasilitasi gaya belajar visual, auditori, dan kinestetik. Penelitian ini menggunakan model pengembangan 4D yang terdiri atas tahap *Define, Design, Develop,* dan *Disseminate.* Instrumen penelitian yang digunakan mencakup lembar validasi ahli materi dan ahli media serta angket respons siswa untuk mengukur kepraktisan produk. Media pembelajaran dikembangkan menggunakan platform Unity berbasis Android agar dapat diakses secara luas oleh siswa. Hasil validasi ahli materi menunjukkan kategori sangat layak, dan validasi ahli media juga memperoleh kategori sangat layak. Uji kepraktisan berdasarkan respons siswa menunjukkan hasil yang positif, baik pada uji terbatas maupun uji lapangan, yang keduanya termasuk dalam kategori sangat praktis. Berdasarkan hasil penelitian pengembangan multimedia interaktif dengan pendekatan berdiferensiasi yang dikembangkan dinyatakan layak dan praktis untuk diimplementasikan sebagai media pembelajaran yang responsif terhadap kebutuhan belajar siswa terhadap materi algoritma pengurutan sesuai dengan gaya belajar masing-masing siswa.

Kata Kunci: Algoritma Pengurutan; Model 4D; Multimedia Interaktif; Pendekatan Berdiferensiasi

Abstract
Sorting algorithm material, which is part of computer science learning, has abstract characteristics that make it difficult for students to understand the concepts and logic of the process. This problem is further complicated by the use of non-interactive learning media that do not yet accommodate students' different learning styles. Therefore, this research aims to develop interactive multimedia with a differentiated approach to facilitate visual, auditory, and kinesthetic learning styles. This research uses the 4D development model, which consists of the Define, Design, Develop, and Disseminate stages. The research instruments used include expert validation sheets for content and media experts, as well as student response questionnaires to measure the practicality of the product. The learning media was developed using the Android-based Unity platform so that it could be widely accessed by students. The results of the material expert validation showed a very feasible category, and the media expert validation also received a very feasible category. The practicality test based on student responses showed positive results, both in the limited test and the field test, which were both included in the very practical category. Based on the results of the interactive multimedia development research with a differentiated approach that was developed, it is stated to be feasible and practical for implementation as a learning medium that is responsive to students' learning needs regarding sorting algorithms material according to each student's learning style.

Keywords*: Sorting Algorithms; 4D Model; Interactive Multimedia; Differentiated Approach*

To cite this article:
Istiqomah, T. D. & Ningsih, P. R. (2025). Development of interactive multimedia with a differentiated approach to the material of sequencing algorithms for high school students. *JKTP: Jurnal Kajian Teknologi Pendidikan, 8*(4), 270–283. doi: 10.17977/um038v8i42025p270-283

INTRODUCTION

The Industrial Revolution 4.0 is driving a rapid transformation in global technological development and having a substantial impact on all dimensions of human life, including education. This global digital transformation is pushing education systems in various countries to adapt to develop human potential with adaptive and innovative abilities in the era of modern global competition (Kusuma & Muharom, 2024). The need for 21st-century skills, such as critical thinking, creativity, collaboration, and problem-solving, is becoming increasingly urgent (Thornhill-Miller et al., 2023).

Indonesia responded to this global challenge by launching the Independent Curriculum (Curriculum Merdeka), developed by the Ministry of Education, Culture, Research, and Technology as part of national education reform. This curriculum has been implemented in stages since the 2022/2023 academic year, with the aim of preparing Indonesia's young generation to face increasingly complex global challenges and social change. Based on Decree of the Head of the Education Curriculum Standards and Assessment Agency No. 022/H/KR/2023, 142,663 domestic schools and 35 international schools have been targeted for implementation of the Independent Curriculum.

Learning in the Independent Curriculum is more flexible and tailored to student needs (Marzoan, 2023). This curriculum provides students with the freedom to explore their abilities according to their interests and talents, and allows teachers and educational institutions to design operational curricula relevant to the characteristics of their schools. Given the diversity of students, who have different abilities, experiences, and learning styles (Ulfah et al., 2021), learning approaches need to be adapted to be effective. Teachers must understand this diversity by providing learning services tailored to each individual's needs, allowing students to deepen concepts and strengthen competencies through differentiated learning.

Differentiated learning is an approach that incorporates student diversity in learning activities by exploring and addressing learning responses according to their individual characteristics (Fauzia & Hadikusuma Ramadan, 2023). In principle, schools should focus on supporting students to develop their maximum potential, rather than simply meeting established standards (Prabawati et al., 2024). According to Tomlinson (2000), differentiated learning emphasizes three key aspects that teachers must consider to meet students' learning needs and ensure they effectively absorb the material. The first aspect is readiness to learn, which refers to students' ability to absorb new material. The second aspect is student interest, which is an important motivator for active engagement in learning. These three aspects of a student's learning profile are influenced by various factors such as language, culture, health, family circumstances, and learning style preferences.

Learning style is an individual's tendency to adopt certain learning strategies through the process of seeking and trying various approaches that suit their needs in understanding and processing information (Derici & Susanti, 2023). Learning styles can be grouped into three main types: visual, auditory, and kinesthetic, often abbreviated as VAK. To meet these needs, effective media are needed to deliver material so that learning objectives are optimally achieved (Wibowo et al., 2022). Media functions as an intermediary in conveying messages (Pangesti et al., 2025). One medium that can support various learning styles is interactive multimedia, which can provide engaging learning experiences while adapting to student needs.

Interactive multimedia is the integration of various media forms such as text, images, graphics, sound, animation, video, and interactive elements, presented in digital format to convey information effectively to the public (Manurung, 2020). Interactive multimedia is a device equipped with control features, allowing users to operate or select options according to their preferences (Mazda & Fikria, 2021). One rapidly growing platform is Android-based applications. Android applications are software specifically designed to run on the Android operating system, with various features that can be utilized, including for educational purposes (Fauzi et al., 2025).

Questionnaire results showed that most students still experience difficulties in understanding sorting algorithms, particularly Insertion Sort and Bubble Sort, and in designing algorithms. Furthermore, students stated that the learning media used was monotonous, lacked interactivity, and did not suit their learning styles, thus under-representing the material.

Interviews at SMA Negeri 1 Kamal, which has implemented the Independent Curriculum with Informatics as a subject, include sorting algorithms. However, most students still experience difficulties in understanding the material. These challenges are caused by weak foundational knowledge, the transition from junior high to senior high school, and differing interests in technology. Learning that emphasizes theory without real-life case studies makes it difficult for students to understand algorithm patterns. The available learning media, such as the use of manual cards, have not been arranged systematically and are less appropriate with technological developments. Furthermore, differences in students' understanding levels and varying learning styles, including visual, auditory, and kinesthetic, further exacerbate these barriers. These conditions result in low student motivation, enthusiasm, and interest in learning sorting algorithms.

This research, supported by previous research conducted by Ekaningtiass et al. (2023), found that technology-based differentiation learning media in Indonesian language learning, particularly for procedural texts, was effective. Furthermore, research conducted by Purwanto & Dwi Gita (2023) produced a differentiated mathematics learning media based on Android that is easy to use and enhances student learning experience.

Based on these challenges, the purpose of this research is to develop interactive multimedia with a differentiated approach for learning sorting algorithms to suit various student learning styles. The resulting media is expected to be feasible, practical, easily accessible via Android, and capable of increasing student motivation, creativity, activeness, and understanding of sorting algorithms.

METHOD

The research and development method used is R&D (Research and Development). In this study, the 4D model (Define, Design, Develop, and Disseminate) is used as the development model to be applied. The 4D development model is an approach designed to develop various types of learning media broadly, so that it can be used in creating various forms of learning media (Thiagarajan et al., 1974). The 4D development model consists of 4 main stages, namely Define, Design, Develop, and Disseminate (Hamdani, 2011); (Marlina, 2023). The following stages of the 4D model development are in Figure 1.

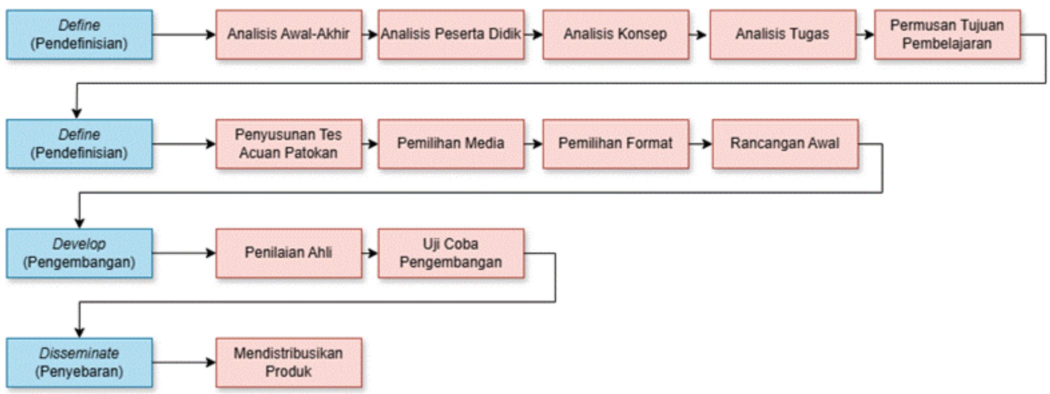

Figure 1. Stages of Development Procedure

This research was conducted through four development stages. The first stage was definition, which included a preliminary analysis to identify learning problems in sorting algorithms through teacher interviews, particularly the lack of media suited to students' learning styles. Next, a student analysis was conducted using a questionnaire to determine characteristics, obstacles, and learning needs. A concept analysis was conducted for learning (TP), followed by a task analysis to determine the basic skills required and to design assignments suited to students' learning styles. This stage concluded with the formulation of learning objectives related to the understanding and application of sorting algorithms.

The second stage was design, which included the development of benchmark tests in the form of diagnostic tests and final tests tailored to the learning objectives and students' learning styles. This stage also included the selection of Android-based media with interactive visualizations and drag-and-drop features, the determination of the format of interactive multimedia content consisting of text, images, audio, and simulations, and the creation of initial designs in the form of flowcharts and storyboards aligned with the concept of differentiated learning.

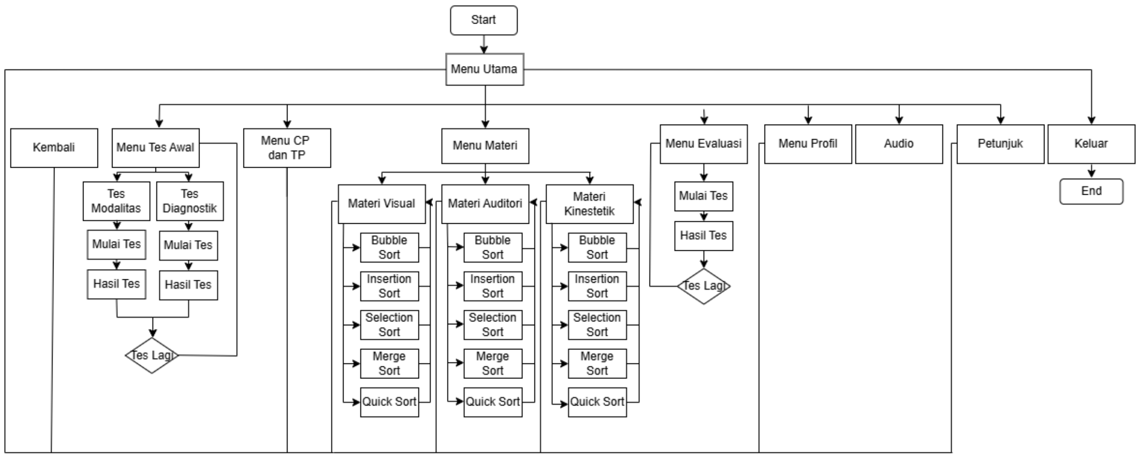

Figure 2. Product Development Flowchart

The flowchart in Figure 2 illustrates the workflow of differentiated interactive learning media, starting from the Start page and moving to the Main Menu, which contains the Initial Test, CP & TP, Materials, Evaluation, Profile, Audio, Instructions, and Exit features. The Initial Test includes a Modality Test to identify students' learning styles (visual, auditory, and kinesthetic) and a Diagnostic Test to measure initial abilities. The Materials menu displays three presentation modes: visual, auditory, and kinesthetic, with content algorithms such as Bubble Sort, Insertion Sort, Selection Sort, Merge Sort, and Quick Sort. The Evaluation menu is used for practice questions and displaying results, while other menus provide information, adjust sound settings, guide, and exit the application.

The third stage is development, which begins with validation by material experts and media experts to assess the feasibility of the content and design. This is followed by a phased development trial, a limited trial, and a field trial. This study conducted a limited trial with six students and a field trial with 21 students.

The final stage is dissemination, which involves disseminating validated and tested interactive multimedia products to users so they can be utilized in learning activities. In addition, we obtain data on their learning experiences while using the multimedia based on their learning styles. This learning experience serves as a reflection for further development and implementation.

Table 1. Subject Matter Expert Questionnaire Grid

Aspect	Indicator
Content Eligibility	Suitability of material with learning outcomes
	Clarity of the material presented
	The material is arranged logically according to the stages of the sorting algorithm.
	Structured material
	The correspondence between the progress of thought and the level of difficulty faced by students
	Practice questions according to the material on sorting algorithms with a differentiated approach
	Suitability of the sorting algorithm material and students' needs
	Completeness of materials
	Suitability of providing material examples
	Easy to understand material
Linguistics	Informative and communicative language
	Cognitive level match with language
Evaluation Questions	Suitability of questions to the material presented
	Answer key compliance
	Questions are tailored to a differentiated approach.

Data collection techniques are strategies for obtaining information in accordance with the research design. Selecting the right method will produce valid and reliable data, while inappropriate methods can reduce data quality (Kesumaningrum et al., 2021). The instruments used in this research data collection were expert validation sheets and student response questionnaires.

Table 2. Media Expert Questionnaire Grid

Aspect	Indicator
Interactive Multimedia Components	Appealing initial display
	Suitability of title to content
	Clarity of instructions
	Completeness of identity
	Attractiveness of interactive multimedia design
	Practice questions related to the material on sorting algorithms using a differentiated approach
Display Arrangement	Ease of use of buttons
	Easy-to-read text
	Attractive color design
	Relevant images and illustrations are used to support understanding of the material
	Attractive and appropriate layout
	Interesting song arrangements
Interactivity	Engaging and easy-to-understand language
	Interactive features that actively engage students
Overall Rating	The ability of interactive multimedia to attract students' attention
	The ability of interactive multimedia as a learning resource
	Interactive multimedia meets students' needs
	Interactive multimedia supports the achievement of learning outcomes

The trial instruments by subject matter experts were used to assess the appropriateness of the content, including the suitability of the material to learning outcomes, the accuracy of the sequencing algorithm concepts, the structured presentation, the suitability of cognitive levels, and the quality of the language and evaluation (Modifikasi: Febrianti *et al.,* (2021) dan Astri *et al.,* (2022)).

The trial instruments carried out by media experts focused on display design, interactivity, and technical aspects, such as layout consistency, ease of navigation, text readability, use of animation/audio, and interactive feature functions (Modification: Febrianti et al., (2021) and Astri et al., (2022)).

Table 3. Student Response Questionnaire Grid

Aspect	Indicator
Interactive Multimedia Components	Interactive and engaging multimedia displays
	Suitability of interactive multimedia content
	Animations displayed in interactive multimedia
	Good image clarity in interactive multimedia
	Music matches interactive multimedia content and displays
	Easy-to-use button/navigation functions
Display Arrangement	The material presented is easy to understand.
	The text/writing layout is clear and easy to read.
	The interactive multimedia design is attractive and uses attractive colors.
	The interactive multimedia layout is attractive and appropriate.
	The song arrangements used are interesting.
Presentation of Material	Ease of understanding interactive multimedia material
	Use of clear and easy-to-understand language
	A variety of engaging images
	Visuals and animations support understanding of the material.
	Use of examples relevant to the material being presented
	Questions or problems that are relevant to the material being taught
Differentiated Approach	Providing a variety of learning media (visual, audio, and kinesthetic)
	Providing graded levels of questions (easy, intermediate, and difficult) in multimedia

The student response questionnaire instrument was used to assess media attractiveness, ease of use, usefulness of the material, and the application of a differentiated approach through variations in visual, audio, and kinesthetic presentation in learning sequencing algorithms using a differentiated approach (Modifikasi: Febrianti *et al.,* (2021) dan Marlina, (2023)).

The data obtained were analyzed quantitatively and qualitatively. Quantitative descriptive analysis presents data in the form of numbers or percentages to draw general conclusions, while qualitative descriptive analysis processes data systematically using words or categories to provide a comprehensive picture of the object being studied (Kesumaningrum et al., 2021). Quantitative descriptive data analysis was used to assess the feasibility and practicality of interactive multimedia through expert validation and student responses. The assessment was conducted using a Likert Scale (1–5) and calculated using percentages (El Hikam & Malasari, 2023). The expert validation results showed that the material and media were valid, while student responses were used to assess the level of practicality. Based on the accumulation of expert validation results and student responses, the product was then declared suitable for use . The percentages obtained were then categorized into criteria as shown in Table 4 (Hasibuan & Megalina, 2024).

Table 4. Feasibility and Practicality Criteria

No	Range of Values	Description
1	81%-100%	Very Feasible/Very Practical
2	61%-80%	Feasible/Practical
3	45%-60%	Fairly Feasible/Fairly Practical
4	21%-44%	Not Feasible/Not Practical
5	<20%	Very Not Feasible/Not Practical

RESULT

This research produces interactive multimedia-based learning media with a content differentiation approach to the sorting algorithm material, which is developed using Unity and implemented on Android devices. Referring to the Differentiated Instruction concept proposed by Tomlinson (2000), content differentiation is implemented by providing a variety of material presentation formats to suit the needs of various student learning profiles.

The development process followed the 4D model (Define, Design, Develop, and Disseminate). In the Define stage, interviews with informatics teachers at SMAN 1 Kamal revealed that algorithm learning was still dominated by lecture methods, the media used was unstructured, and students' learning style differences were not accommodated. These findings were reinforced by questionnaire results, which showed that most students experienced difficulties with Bubble Sort and Insertion Sort and required interactive media.

Based on this, development focused on implementing content differentiation, namely providing material in several presentation formats that could be selected according to students' learning preferences. The interactive media developed presented the Bubble Sort and Insertion Sort algorithms in three main presentation modes: visual, auditory, and kinesthetic.

Figure 3. Material Content Menu

In visual mode, the material is presented in the form of static and dynamic visualizations designed to be as attractive as possible to make it easier for students to understand the sequential workflow of the algorithm. The design using Canva with a simple yet informative design approach. The Insertion Sort process is visualized from a random state to a neatly arranged data. Each step is shown through a number box illustration, accompanied by directional arrows and brief descriptions showing the process of inserting elements into the appropriate location. This presentation allows students to understand the sorting pattern without having to read lengthy explanations.

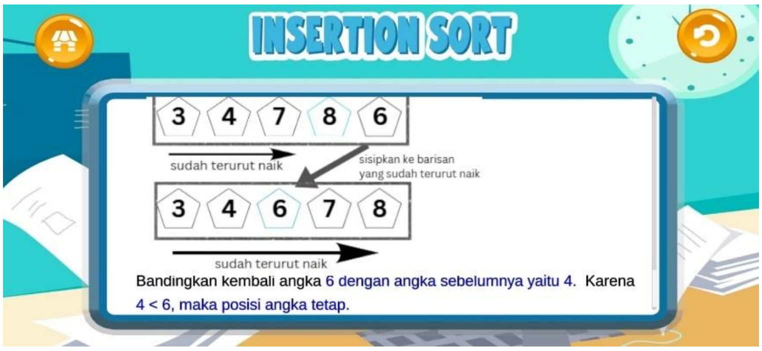

Figure 4. Visual Material Content

For students with auditory tendencies, the material is presented in the form of animated videos with explanatory voice-over narration. The videos were developed using Canva, combining visual elements, light text, animations of moving data elements, and audio recordings that explain each process in a coherent manner. In the Bubble Sort animation, numbers are visualized as bubbles swapping locate. Each element's movement is accompanied by narration such as "the first element is compared with the second element; if it is larger, it is swapped." This combination of animation and audio explanations allows auditory students to grasp concepts without being fixated on text.

Figure 5. Auditory Material Content

To accommodate kinesthetic learners, the media provides a drag-and-drop sorting simulation, where users are asked to directly sort elements by dragging and placing them in the correct positions as shown in the image. The system provides automatic feedback in the form of animation or sound when the steps taken are in accordance with the algorithm. If a step is incorrect, the element will return to its original position, encouraging students to try again. This mechanism creates an active, exploratory, and hands-on learning experience, so that the concept of the algorithm is not only understood cognitively but also experienced through action.

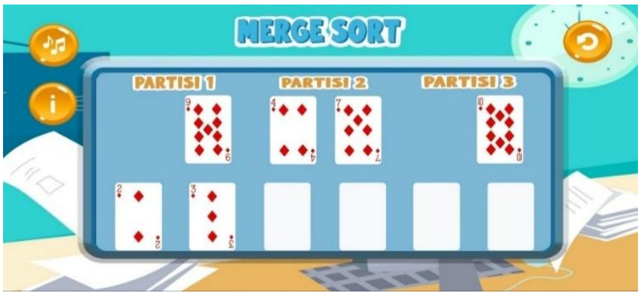

Figure 6. Kinesthetic Material Content

The design phase involved developing a benchmark test. Diagnostic tests indicated that most students were in the low to moderate ability category, with a predominance of visual learning styles. Therefore, the final test was designed to be more varied, tailored to their abilities. Android-based media, with animations, simulations, and drag-and-drop features, were chosen to enhance student interest, motivation, and understanding. The content format included animations for visual learners, audio narration for auditory learners, and drag-and-drop interactions for kinesthetic learners, along with real-time feedback.

In the development phase, the resulting interactive multimedia learning media was revised based on expert assessment and student trials. This phase included assessments from subject matter experts and media experts to ensure product feasibility before further implementation. The validation results are presented in Table 5.

Table 5. Expert Validation Results

NO	VALIDATOR	TOTAL SCORE	VALIDATION PERCENTAGE
1	Content expert I	64	85 %
2	Content expert II	74	99 %
3	Media expert I	83	92 %
4	Media expert II	88	98 %
	TOTAL	309	93,5 %

In addition to quantitative assessments, the validators also provided constructive qualitative feedback to improve the product being developed. This feedback covered various aspects, such as interface appearance, material clarity, and media suitability for learning objectives. Details of the qualitative feedback from each validator can be seen in Table 6.

Table 6. Revision Results

Suggestions/Comments	Before Revision	After Revision
The material expert suggested improving the images used in the material by collecting them in boxes to make it easier for students to understand.		
Media experts suggest adding a home button, as previously there was only a back button.		

After being declared suitable through the validation process, the learning media was then tested on students as research subjects. The trials were conducted in stages, starting with small-scale trials and then moving on to larger-scale trials to assess the media's effectiveness more broadly. The results of both testing stages are presented in detail in Table 7.

Table 7. Trial Results

NO	VALIDATOR	RESPONDENTS	Learning Style			TOTAL SCORE	VALIDATION PERCENTAGE
			Audio	Visual	Kinesthetic		
1	Terbatas	6	2	2	2	528	93 %
2	Lapangan	21	7	7	7	1915	96 %
TOTAL						2443	94,5 %

Analysis of the results of the content differentiation implementation showed an increase in student interest and understanding of the sorting algorithm material. Nine visual learners stated that the animation helped them understand the logical sequence quickly, while nine auditory learners felt the voice narration made it easier to grasp the concept without having to read lengthy text. Furthermore, nine kinesthetic learners demonstrated the highest participation rate, with a shorter simulation completion time. Overall, 94.5% of students found the media engaging and suited their learning styles.

In the dissemination stage, the validated and tested interactive multimedia was distributed to teachers and students for use in learning. The product was shared directly with teachers and uploaded to Google Drive (https://bit.ly/SortingAlghoritm) for anytime access. Thus, this media is expected to facilitate sorting algorithm learning that is more suited to students' learning styles.

DISCUSSION

This research produced an Android-based interactive multimedia with a content differentiation approach on sorting algorithm material developed using Unity. The development followed the 4D model (Define, Design, Develop, Disseminate). In the Define stage, needs analysis was conducted through interviews and questionnaires, identification of students' difficulties in understanding sorting algorithms, determination of core material, and formulation of learning objectives. The Design stage focused on media design based on the results of learning style tests, creation of storyboards, flowcharts, graphic assets, and integration into Unity. The Develop stage included expert validation and trials, thus demonstrating a high level of feasibility and practicality. Based on the results of validation by two material experts, a percentage of 92% was obtained with a very feasible category, while validation by two media experts obtained a score of 95% with the same category. The results of trials on students at SMAN 1 Kamal also showed an increase in the level of practicality from 93% in limited tests to 96% in field tests, which is included in the very practical category. These findings indicate that the developed media not only meets the feasibility standards in terms of material and technical aspects, but also suits students' learning needs and is easy to use in daily learning activities. The Disseminate stage is carried out by distributing the product to teachers and students via Google Drive so that it can be accessed flexibly on Android devices.

The results of this development align with the Differentiated Instruction theory proposed by Tomlinson (2000), which emphasizes the importance of adapting learning to the needs, readiness, and learning styles of students. The content differentiation approach in this study is realized through the provision of three main presentation formats: visual, auditory, and kinesthetic, allowing students to choose learning methods according to their individual preferences. The implementation of this strategy aims to bridge the understanding gap between students with different learning styles, particularly in understanding abstract and procedural algorithmic material. This approach was chosen because it aligns with the principles of learner-centered learning, where the learning process is directed so that each individual can achieve their competencies in the way that best suits them.

In the context of Informatics learning, variations in learning styles are a crucial factor in determining the success of understanding the concept of sequencing algorithms. According to Sebri (2022), students with a visual learning style more quickly grasp logical patterns through pictorial and diagrammatic representations, while auditory learners rely on narrative, rhythm, and verbal explanations to build sequential understanding. Meanwhile, kinesthetic learners more easily grasp concepts when directly involved in practical activities and interactive exploration. Therefore, the media developed in this study was designed to provide an adaptive learning experience for all learning style profiles, so that each student has an equal opportunity to understand the material through an approach that best suits their learning characteristics.

The findings of this study also support the theory of content differentiation proposed by Tomlinson (2000), which states that variations in information presentation allow students to access learning according to their cognitive profiles, interests, and learning preferences. By providing content in three main formats: text and animation for visuals, voice narration for auditors, and drag-and-drop activities and interactive simulations for kinesthetics, this media not only enhances algorithmic comprehension but also fosters independent learning and active student engagement throughout the learning process. This indicates that implementing content differentiation can create a more inclusive and personalized learning experience, where each student can set their own learning pace and strategies according to their learning style.

The practical implication of these findings is that teachers can utilize the developed interactive media as an adaptive tool for Informatics learning in heterogeneous classrooms. This media can be integrated both independently and as part of project-based learning, where students are given the opportunity to explore and solve real-world problems through the use of interactive features within the application. Thus, the teacher's role shifts from merely conveying information to being a facilitator who directs and adapts learning strategies based on students' learning profiles. Furthermore, these results reinforce the relevance of applying differentiation theory in digital learning contexts, particularly in materials that require an understanding of algorithmic logic and procedural step processing.

In the visual mode, students demonstrated an increased understanding of the workflows of the Bubble Sort, Insertion Sort, and Selection Sort algorithms through the presentation of static and dynamic visualizations that clearly illustrate the comparison and swapping processes. Contrasting colors, arrow directions, and brief explanations of each step were shown to help students construct a mental representation of the algorithm's logical sequence. Based on observations and interviews, most students stated that the animated displays made it easier to understand sorting patterns without having to read lengthy text.

In the auditory mode, the integration of animated data element movements with voice narration had a positive impact on student engagement and focus. Narration explaining steps such as "the first element is compared with the second element, if it is larger, swap them" helps auditory learners understand algorithmic processes coherently. Students with auditory tendencies stated that they found it easier to follow material through audio explanations than reading text.

Meanwhile, in kinesthetic mode, the interactive drag-and-drop sorting feature provides an active and challenging learning experience. Students can directly practice the sorting process by dragging elements to the correct positions, and the system provides automatic feedback in the form of animations and sounds when actions are correct or incorrect. Based on trial results, kinesthetic learners were more enthusiastic about using this mode because they could learn through hands-on practice. This feature not only increased learning motivation but also strengthened their procedural understanding of the algorithm.

Field trial results showed that each learning style group benefited differently from the features provided. Seven students with a visual learning style stated that the visual animations helped them understand the algorithm steps more quickly and clearly. Meanwhile, seven auditory learners found that videos with audio narration helped them focus better and were able to follow the logical flow without having to read lengthy text. Meanwhile, seven kinesthetic students demonstrated the highest level of engagement through drag-and-drop activities, which facilitated their understanding of algorithm concepts through hands-on experience. This finding reinforces Wulandari & Wardhani's (2024) learning style theory, which states that diverse learning media will be more effective if tailored to students' dominant sensory characteristics.

In addition to content differentiation, learning media plays a crucial role in supporting the learning process because it encompasses all the tools or means used to convey messages and can stimulate students' thoughts, feelings, attention, and motivation, thus supporting the learning process (Fikri & Madona, 2018). With the advancement of Information and Communication Technology (ICT), transformations are occurring. One form of innovation relevant to the needs of 21st-century education is interactive multimedia. Interactive multimedia is a system that integrates various media forms such as text, images, video, animation, and sound into a single learning platform, enabling direct interaction between users and the system. The presence of interactive quiz features with automatic feedback supports the principle of feedback immediacy, which plays a crucial role in digital learning, strengthening conceptual understanding and encouraging self-regulated learning. This system functions as a tool that clarifies the delivery of material efficiently and engagingly (Mustika et al., 2023). Through this feature, students can quickly identify errors, correct them independently, and reflect on their thinking processes, thus making learning more active, adaptive, and meaningful.

The results of this study align with the findings of Ekaningtiass et al., (2023), who reported that the development of Android-based interactive multimedia with animation integration and automatic evaluation increased the media's feasibility by 91% among experts and 94% among users. These findings are also consistent with research by Rahmi & Baharuddin (2021) which shows that the implementation of differentiated learning can increase student motivation and participation because it adapts to individual characteristics. Furthermore, research by Salsabila et al. (2024) confirms that the use of interactive media based on digital simulations effectively improves algorithmic understanding, particularly for concepts requiring procedural understanding, such as sorting.

Therefore, the results of this study extend previous findings by adding a dimension of content differentiation that adapts to visual, auditory, and kinesthetic learning styles.

Based on the test results, the main advantage of this product is its ability to accommodate three learning styles simultaneously within a single platform. The combination of text, animated visualizations, voice narration, and interactive simulations makes this media flexible for use in various learning contexts. Furthermore, because it was developed on an Android platform, the media can be easily accessed without the need for special devices. However, this study also has limitations. The testing was limited to a small sample size in one school, so the generalizability of the results needs to be expanded to more diverse contexts and populations. Furthermore, the variety of digital physical activities for students with kinesthetic learning styles can still be refined to make the interactive experience more dynamic, contextual, and stimulating multisensory engagement.

CONCLUSION

Based on the results of the development research and data analysis conducted on interactive multimedia with a differentiated approach using the 4D development model, it can be concluded that the Android-based interactive learning application developed using Unity supports independent learning activities according to each student's learning preferences. This media is easy to use, suits learning needs, and is included in the category of being very suitable for use in learning. This study recommends that teachers utilize this interactive multimedia as an alternative medium in Informatics learning, and further research can expand testing in different school contexts.

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