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The Development of Interactive Multimedia on The High School's Nanotechnology

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ABSTRAK

Nanoteknologi merupakan salah satu materi kimia yang baru di dalam Kurikulum Merdeka. Sumber belajar nanoteknologi yang sesuai dengan tingkat kognitif peserta didik SMA sangat minim, sehingga diperlukan media pembelajaran yang membantu peserta didik untuk memahami materi. Penelitian ini bertujuan untuk: (1) menghasilkan multimedia interaktif yang memenuhi kriteria kelayakan dan (2) mengetahui respon peserta didik terhadap multimedia interaktif. Model pengembangan ADDIE digunakan dalam penelitian ini. Sebanyak 10 orang peserta didik kelas X SMA Pangudi Luhur Sedayu menjadi sampel dalam uji coba terbatas. Hasil penelitian menunjukkan bahwa: (1) produk memenuhi kriteria kelayakan dengan rata-rata presentase 89% memenuhi kriteria sangat layak; memenuhi kriteria sangat valid dengan rata-rata 88,7% memenuhi kriteria sangat efektif dengan rata-rata 87%, memenuhi kriteria sangat praktis dengan rata-rata nilai 89%; (2) respon peserta didik terhadap produk sangat baik dan mendapatkan komentar yang baik. Multimedia interaktif yang dikembangkan dapat digunakan untuk mendukung proses pembelajaran nanoteknologi di SMA.

ABSTRACT

The lack of learning resources and media on nanotechnology, a new topic in the High School Merdeka curriculum, poses a challenge for teachers. Therefore, high school students in Indonesia still need to use interactive multimedia in learning activities to help them grasp the material. This research aims to (1) create interactive multimedia products that meet the eligibility criteria and (2) understand students' responses to such media. The ADDIE development model was employed in this study. A total of 10 students from class X SMA Pangudi Luhur Sedayu were sampled in the limited trial. The results indicated that: (1) the product meets the eligibility criteria with an average percentage of 88.7% fulfilled very feasible criteria; fulfilled very valid criteria with an average of 88,7%, fulfilled very effective criteria on an average of 87, fulfilled very practical criteria with an average of 89%; (2) the response of students to the product is very good and gets good comments. The developed interactive multimedia can effectively support the learning process of nanotechnology in senior high schools.

1. INTRODUCTION

Nowadays, technological development occurs rapidly across numerous fields, significantly impacting the educational domain. The swift advancement of technology in the 21st century necessitates the educational system to play a pivotal role in enhancing the abilities and skills of human resources to compete in the era of society 5.0. The development of the educational system is imperative to nurture a creative, innovative, and competitive generation in this era (Anwar 2022). Developing a curriculum is one of the strategies for adapting the education system to current developments and enhancing the quality of education.

In Indonesia, the curriculum is periodically developed to align with advancements in science and technology. In its implementation, the curriculum in Indonesia has undergone various changes and improvements (Ananda and Hudaidah 2021). The current curriculum being developed is the Merdeka curriculum. This curriculum emphasizes intracurricular learning and strengthens the Pancasila profile to foster the competencies and character of educational participants (Kemendikbudristek 2022). As a

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provision for human resources in Indonesia to compete in the era of Society 5.0, the high school-level independent curriculum introduces new materials not present in the 2013 curriculum revision, such as the sub-material on nanotechnology within atomic structure. The inclusion of new material like nanotechnology in the curriculum, it poses a challenge for teachers in teaching, necessitating teachers to comprehend this material while also acquiring specialized skills to convey it.

Nanotechnology is a field that manipulates materials at the nanoscale size (1-100 nm). It gained public attention in the early 2000s (Bayda et al. 2019). Nanotechnology finds applications in various sectors, including agriculture, food industries, medications, cosmetics, and more (Malik, Muhammad, and Waheed 2023). Its rapid growth is attributed to its effectiveness and efficiency in terms of high surface area, shape, size, stability, and other factors (Ahire et al. 2022).

Based on interviews with high school teachers, it was found that they require assistance in implementing the Merdeka curriculum due to the lack of specific guidelines concerning this new material. Only a few high school teachers utilize interactive multimedia in their teaching and learning processes, as per the gathered information. One approach to mitigate teachers' challenges is by employing learning media to facilitate the conveyance of lesson material. Learning media serves as a tool to support the learning process by cultivating students' comprehension of the material and motivating them to learn (Putri, Elvia, and Amir 2021). Interactive multimedia, an implementation of technological advances, amalgamates audio, animation, video, text, and images, offering students a direct independent learning experience through navigation buttons (Manurung 2021). Interactive multimedia also alleviates boredom and encourages student engagement (Anam and Tijan 2022). Furthermore, multifaceted interactive media has been shown to enhance students' understanding of chemical material and increase their activeness and interest in the learning process (F, Rohiat, and Elvinawati 2022).

Nanotechnology material was chosen as the subject for interactive multimedia development due to its novelty in the Merdeka curriculum, resulting in limited available resources for the high school level. This interactive multimedia was developed using the Smart Apps Creator 3 application and the ADDIE research and development model. The multimedia is designed to incorporate text, videos, and images to enhance learning engagement. Additionally, it is interactive, featuring navigation buttons for user interaction and feedback provision. The developed interactive multimedia aids students in comprehending nanotechnology material.

2. METHOD

This research utilized the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model for research and development, as illustrated in Figure 1. The **analysis** phase involved identifying the concept and the necessity for interactive multimedia in the teaching and learning process, which was followed by the design phase. In the **design** phase, the surface of the interactive multimedia, as well as the materials and tests utilized within the interactive multimedia and posttest, were developed. The **development** phase entailed creating the interactive multimedia using Smart App Creator 3, followed by the validation and revision of the interactive multimedia. Subsequently, the **implementation** phase involved deploying the interactive multimedia to students in high school grade X. Following the trial, a questionnaire was administered to the students to solicit feedback regarding the interactive multimedia. The results from the validation process and questionnaire were utilized in the **evaluation** phase.

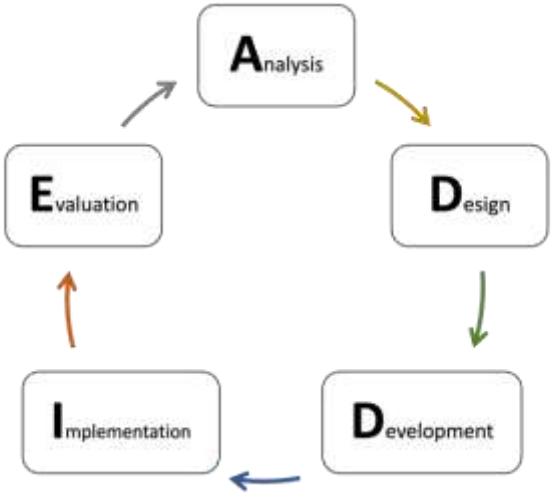

Figure 1. The scheme of ADDIE research and development model

The product validity and questionnaire criteria were assessed using the Likert scale with the specifications listed in Table 1.

Table 1. Likert Scale for Content Validity and Questionnaire

No	Score	Content validity category	Questionnaire category
1	4	Very good	Strongly agree
2	3	Good	Agree
3	2	Poor	Disagree
4	1	Very poor	Strongly disagree

The analysis of validation and student questionnaire utilized the formulas and criteria listed below (Table 2, 3 and 4), respectively:

$$PS = \frac{n}{N} x100\% \qquad (1)$$

Where PS is the percentage score, n is the total score obtained, and N is the maximum score.

Table 2. Criteria for Product Validity

No	Score (%)	Product Validity Category
1	81-100	High Validity
2	61-80	Valid
3	41-60	Moderate Validity
4	0-40	Invalid

Content validity for the test questions was assessed using the Gregory formula (2007).

		Weak relevance (item rated 1 or 2)	Strong relevance (item rated 3 or 4)
Expert Judge 2	Weak relevance (item rated 1 or 2)	A	B
	Strong relevance (item rated 3 or 4)	C	D

$$Vc = \frac{D}{(A+B+C+D)}$$

Where A is Expert 1 and Expert 2 do not agree, B is Expert 1 does not agree and Expert 2 agrees, C is Expert 1 agrees but Expert 2 does not agree, and D is Expert 1 and Expert 2 agree.

Table 3. Criteria for Question's Content Validity

No	Validity score	Category
1	0.8-1	High
2	0.4 – 0.79	Medium
3	0 – 0.39	Low

The student response questionnaire was analyzed using the formula modified from Akbar (2013:158).

$$\text{Percentage (\%)} = \frac{Total\ student's\ score}{Maximum\ skor}\ x\ 100\%$$

Table 4. Criteria for Student Response Questionnaire

No	Score (%)	Category
1	>75-100	Very good
2	>50-75	Good
3	>25-50	Poor
4	0-25	Very poor

3. RESULTS AND DISCUSSION

Analysis

Considering that nanotechnology will be taught for the first time, there is a need for learning media to assist students in understanding the material (Ayu Permata Sari and Suryelita 2023). Interviews with chemistry teachers at Pangudi Luhur Sedayu High School revealed that interactive multimedia learning tools have not been utilized in the teaching and learning process. Instead, teachers rely on simple learning media such as YouTube, Virtual Laboratory, and PowerPoint presentations. This limitation stems from the teachers' lack of expertise in developing interactive learning materials. Therefore, a product in the form of interactive multimedia focusing on nanotechnology material has been developed to support the learning process.

Design

In the design phase, the interactive multimedia interface (Figure 2) incorporates several buttons, including *Petunjuk*, *Capaian Pembelajaran (CP), Tujuan Pembelajaran (TP), Alur Tujuan Pembelajaran (ATP), and Profil Pelajar Pancasila (PPP), Materi, Evaluasi dan Referensi*. The *Materi* button leads to four main topics: the meaning of nanotechnology, the concept of utilizing atomic structures at the nanoscale in nanotechnology, the development of nanotechnology, and nanotechnology applications. The *Evaluasi* button contains ten multiple-choice questions. Subsequently, the material was prepared, followed by questions consisting of four practice questions in true or false format, five discussion forum questions in the form of crossword puzzles, and ten evaluation questions in multiple-choice format. Finally, all designed components were incorporated into Canva for an attractive design.

Figure 2. The interactive multimedia menu's interface

Development

Interactive multimedia development was conducted using Smart Apps Creator 3 to incorporate interactive features into the multimedia. The interactive multimedia includes material presentations, practice questions, forum discussions, and evaluation questions. The developed interactive multimedia products on nanotechnology materials can be accessed via https://bit.ly/mulmedNT, as shown in Figure 3.

Two validators then assessed the interactive multimedia for quality and content. The results of the product validation and content assessment are listed in Tables 5 and 6, respectively. Based on Table 5, the average validity regarding product quality is 84%, indicating that the developed interactive multimedia possesses good text quality, high-quality images and videos, an attractive design, and ease of use. Table 6 demonstrates that the average validity regarding content is 89%; thus, the interactive multimedia contains appropriate material, is comprehensive, and employs suitable language.

Additionally, the interactive multimedia exercise questions, discussion prompts, and evaluation were subjected to validation. The validation outcomes are presented in Tables 7, 8, and 9.

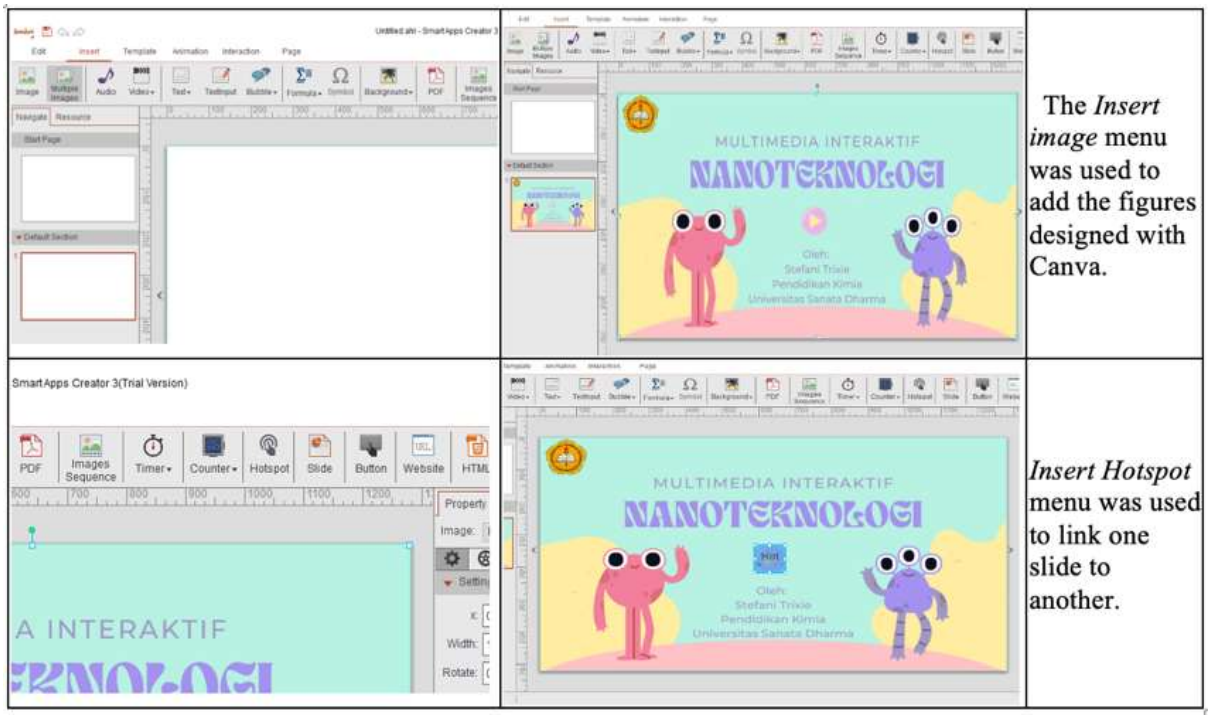

Figure 3. The development of an interactive multimedia interface

Table 5. Summary of Product Quality Validation Results

No	Indicator	Validity (%)	Category
1	Utilization	88	High validity
2	Quality of text, images and videos	84	High validity
3	Design	81	High validity
	Average	**84**	**High validity**

Table 6. Summary of Content Validation Results

No	Indicator	Average	Category
1	Introduction	100	High validity
2	Appropriateness of content	88	High validity
3	Language	79	Valid
	Average	**89**	**High validity**

Table 7. Result of Exercise Questions Validation

No	Question Items	Validity	Category
1	Number 1	1	High validity
2	Number 2	1	High validity
3	Number 3	1	High validity
4	Number 4	1	High validity

Table 8. Result of Discussion Forum Validation

No	Question Items	Validity	Category
1	Number 1	1	High validity
2	Number 2	1	High validity
3	Number 3	1	High validity
4	Number 4	1	High validity
5	Number 5	1	High validity

According to Retnawati (2016), if the validity value exceeds 0.8, it is categorized as high validity, while values falling within the range of 0.4-0.8 indicate medium validity. A valid instrument implies its suitability for measuring the intended construct (Sugiyono 2015). Therefore, based on the data, the exercise questions and discussion forums demonstrate high validity, while the evaluation exhibits both high and moderate validity, suggesting their suitability for measuring students' cognitive aspects.

Table 9. Results of Evaluation Validation

No	Question Items	Validity	Category
1	Number 1	1	High validity
2	Number 2	1	High validity
3	Number 3	1	High validity
4	Number 4	0,8	Moderate validity
5	Number 5	1	High validity
6	Number 6	1	High validity
7	Number 7	1	High validity
8	Number 8	0,8	Moderate validity
9	Number 9	1	High validity
10	Number 10	1	High validity

Another aspect of validation in this interactive multimedia development is the validation of a student response questionnaire, the results of which are listed in Table 10.

Table 10. Results of Student Response Questionnaires Validation

No	Aspects	Average	Category
1	Contents	100	High validity
2	Construction	94	High validity
3	Language	88	High validity
	Average	94	High validity

From these three aspects, the overall average percentage for the validity of the participant's response questionnaire is 94%, meeting the criteria for "very valid." This indicates that the questionnaire can effectively aid students in learning about nanotechnology topics. The student responses developed employ appropriate language according to EYD version 5, feature clear construction, and contain statements relevant to achieving the research objectives.

Implementation

The limited trial involved 10 students from class X, selected based on recommendations from teachers with low, medium, and high cognitive levels. The effectiveness of the interactive multimedia products was assessed based on the average scores of students on exercise questions, discussion forums, and evaluations. According to Arikunto (2013), students with scores above 75 are classified as meeting very high criteria. The average percentage of scores for exercise questions was 93, for the discussion forum was 80, and for the evaluation was 89. Based on these scores, all 10 students met the requirement, as they obtained scores above the minimum criterion of 70. Four groups fulfilled the requirement, while one group did not, as their average score was below 70. However, the evaluation scores met the requirement of obtaining a score equal to or above the minimum criterion. Thus, the results from working on questions in interactive multimedia indicate that over 80% of students achieved good scores, meeting the criteria for effective use in learning. This is supported by Arikunto's (2013) assertion that a product is considered very effective if the average score exceeds 75.

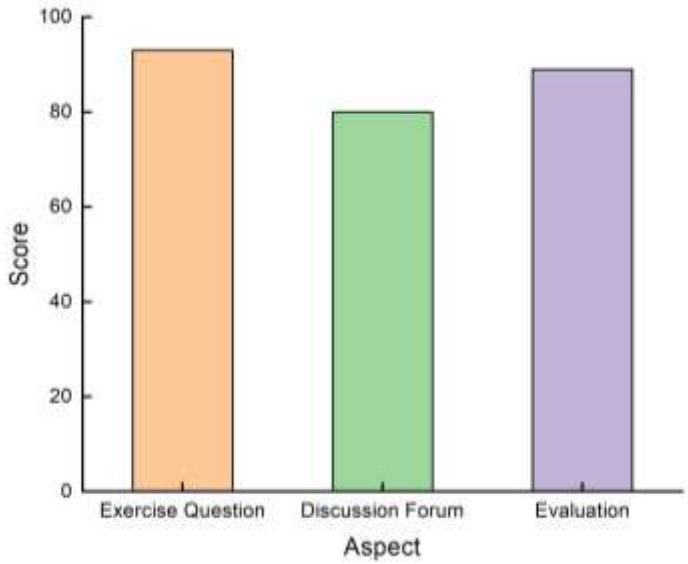

Figure 4. Results of working on questions in interactive multimedia

Following the limited trial, students were asked to complete a questionnaire; the results are listed in Table 11.

Table 11. Results of the Student Response Questionnaire

No	Aspects	Average	Category
1	Operability	88	Very good
2	Learnability	91	Very good
3	Undersability	85	Very good
4	Attractiveness	92	Very good
	Average	89	Very good

Interactive multimedia is easily utilized based on student responses (Akbar, 2016). Several aspects were assessed by students, including operability, related to the ease of operating interactive multimedia; learnability, concerning a deep understanding of its use and the content presented; understanding ability, related to smooth utilization; and attractiveness, related to the interface design. The results of the questionnaire analysis of student responses are displayed in Table 11. The average overall percentage of these aspects is 89%, meeting very good criteria (Riduwan 2008). The results categorize interactive multimedia as very practical, as the average percentage gain exceeds 75% (Riduwan 2013). Therefore, the developed interactive multimedia is highly practical for the nanotechnology learning process.

Evaluation

This research evaluated development activities and implementation based on assessment results and suggestions from validators, chemistry teachers, and student responses through questionnaires. The overall assessment result is satisfactory, but there are still suggestions for improving interactive multimedia. Validators' suggestions primarily revolved around enhancing the completeness of text, layout, image descriptions, question construction, and language use. Based on questionnaire responses, students suggested that parts of questions could be saved when proceeding to the next question. However, due to software limitations, this recommendation cannot be implemented. Results of the interactive multimedia validation analysis regarding nanotechnology material indicate its suitability for learning and fulfilment of valid, effective, and practical criteria.

4. CONCLUSION

Interactive multimedia focusing on nanotechnology has met the criteria for being very valid and feasible, with validation results for product quality at 84% and for content at 89%. Overall, the product validation results achieved a percentage of 88.7%, satisfying very valid and feasible criteria. Furthermore, the validation results indicate an improvement over previous research utilizing an E-module as a learning medium (Ayu Permata Sari and Suryelita 2023). Analysis results revealed that students obtained an average score of 87%, meeting very effective criteria. Additionally, the product satisfies very practical criteria, with the average percentage of student response results at 89%.

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