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Development of interactive *POP ES* multimedia teaching materials based on guided inquiry

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Abstract: *The primary objective was to enhance student engagement, learning outcomes, and motivation. The research was motivated by limited classroom learning time, low achievement levels, and students' lack of enthusiasm, as well as challenges faced by parents in supporting online education. The study employed the Lee and Owens research and development (R&D) framework, which includes five main stages: needs analysis, design, development, implementation, and evaluation.For data analysis, the quantitative data (pre-test and post-test scores) were analyzed using descriptive statistics, particularly to measure the percentage of students achieving learning completeness.The findings indicated that the teaching materials achieved high validity (97% approval from subject matter and media experts), excellent practicality (97% approval from teachers and 92% from students), and strong effectiveness, with 87.5% of students achieving learning proficiency. The study concluded that the developed teaching materials are effective for classroom use, with recommendations for further customization to better align with student competencies.*

Keywords*: Interactive multimedia; guided inquiry; thematic learning; development; learning completeness.*

Introduction

Learning in Indonesia currently adopts the 2013 Curriculum, which emphasizes a scientific and activity-based approach to education. This curriculum encourages learners to engage in five key steps of scientific learning: observing, questioning, collecting information, reasoning, and communicating. These steps aim to build critical thinking and active learning among students. In elementary schools, this scientific approach is integrated within thematic learning, particularly in science subjects.However, in practice, the implementation of this approach in elementary science classes often encounters various challenges. Based on preliminary observations in fifth-grade classrooms, it was found that nearly 50% of students had not reached the minimum criteria for learning completeness. Additionally, students tended to be passive during learning activities. Limited learning time and low parental engagement, especially in the context of online learning, have further hindered effective science instruction.

To address these issues, a more attractive and meaningful learning strategy is necessary. One such promising solution is the use of interactive multimedia teaching materials that adopt a guided inquiry model. This combination is expected to boost students' engagement and motivation while also improving their academic performance. When students interact with digital materials that encourage exploration and discovery, learning becomes more enjoyable and effective.POP ES (Problem-Oriented Project for Elementary Science) is a model that emphasizes problem-solving and student-centered projects tailored to elementary science learning. This model integrates real-life problems into the learning process, encouraging students to develop inquiry skills through hands-on activities and

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collaborative exploration. POP ES is rooted in constructivist learning theory, which argues that learners construct knowledge more effectively when they are actively involved in the process.

The guided inquiry approach, as part of POP ES, aligns well with the demands of the 2013 Curriculum. Guided inquiry differs from traditional instruction in that students are not merely passive recipients of information. Instead, they are guided through carefully structured phases to investigate scientific questions. According to Pedaste et al. (2015), guided inquiry involves orientation, conceptualization, investigation, conclusion, and discussion—making it suitable for primary-level science learning.Multimedia, on the other hand, refers to the integration of various media elements such as text, images, video, animation, and audio to enhance learning experiences. Mayer's Cognitive Theory of Multimedia Learning (2005) posits that students learn better from words and pictures than from words alone. Interactive multimedia supports both visual and auditory learning styles, thus accommodating diverse student needs in the classroom.

The use of interactive multimedia in education has shown significant results in boosting student performance and engagement. Agustina (2016) found that students who used interactive multimedia scored higher in understanding scientific concepts. Multimedia provides simulations, visualizations, and feedback that are often absent in traditional textbooks, which are crucial in grasping abstract concepts such as ecosystems.Previous research also supports the effectiveness of guided inquiry learning. Adiputra (2017) showed that the guided inquiry model enhanced student learning outcomes significantly. Siahaan et al. (2020) added that this approach also improved students' science process skills and concept retention. However, many existing studies focused solely on either guided inquiry or multimedia without integrating the two within a comprehensive model like POP ES.

Therefore, this study introduces an innovative learning model by developing guided inquiry-based interactive multimedia teaching materials within the POP ES framework, specifically on the ecosystem theme for fifth-grade students. This development is aimed at addressing both pedagogical and technological gaps by providing a structured yet engaging learning environment that empowers students to explore and discover. The main problem addressed in this research is: how can guided inquiry-based interactive multimedia teaching materials on the theme of ecosystems enhance motivation, engagement, and learning outcomes of fifth-grade students? The objective is to develop, implement, and evaluate these materials for their feasibility, effectiveness, and practicality. Ultimately, this study aims to contribute to the improvement of elementary science education through the integration of theory-based innovation and contextually relevant instructional design.

Method

This study used a Research and Development (R&D) approach with the Lee and Owens development model to produce inquiry-based interactive multimedia teaching materials that were systematic and tested for effectiveness. The research subjects consisted of fifth grade students at SDN Tasikmadu 1, with trials involving material experts, media experts, teachers, and students. Theresearch instruments included validation sheets, observation sheets, questionnaires, and learning outcome tests, which were designed to measure the validity, practicality, and effectiveness of the teaching materials. Quantitative data was obtained through questionnaires and tests, while qualitative data came from suggestions and responses from experts.

Data collection procedure involved five stages of development: (1) Assessment/Analysis, including needs analysis and comprehensive analysis, (2) Design, in the form of designing interactive multimedia content, (3) Development, product development

according to design, (4) Implementation, field trials with small and large groups, and (5) Evaluation, in the form of revisions based on feedback. Presented in the following chart:

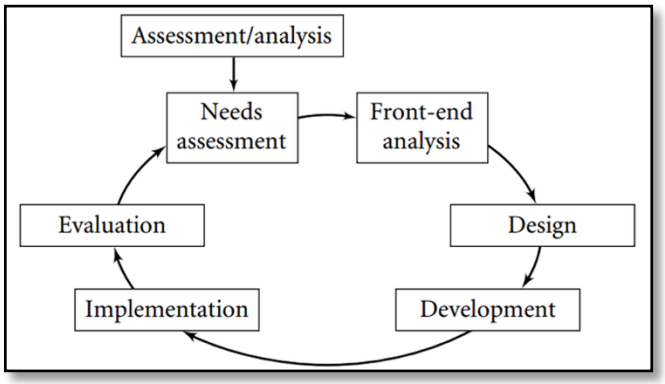

Figure 1. Flowchart of Lee & Owens' Development Design Model (2004: 3)

The analysis employed both quantitative and qualitative descriptive methods. Quantitative data were analyzed using percentages to assess the levels of validity, practicality, and effectiveness, while qualitative data were interpreted narratively based on expert feedback and observations during implementation. The findings indicate that the guided inquiry-based interactive multimedia teaching materials meet the criteria for being valid, practical, and effective.

The data collected during the trials consisted of both quantitative and qualitative types. Quantitative data were derived from questionnaires and tests administered to trial participants, while qualitative data included feedback and suggestions for improvement. Formative evaluations provided data for different purposes:

a. Product validity was assessed using expert reviews, with validation sheets based on modified teaching material instruments (Akbar, 2017: 34), focusing on aspects such as accuracy, relevance, clarity, systematic presentation, student orientation, alignment with national and technological standards, and proper language usage.
b. Observation sheets were used to gather information about the learning process.
c. Questionnaires were distributed to validators and users to evaluate the practicality and appeal of the developed teaching materials, which helped determine their practicality, attractiveness, and effectiveness in limited trials. Assessment sheets captured student learning outcomes, serving as a tool to measure the engagement level facilitated by the inquiry-based interactive multimedia materials.

Results and Discussion

The feasibility assessment conducted by material experts revealed that the inquiry based interactive multimedia teaching materials on the ecosystem theme achieved an average score of 97%, placing them in the "highly feasible" category. As shown in Table 1, all evaluated aspects, including relevance, material structure accuracy, and content up-to-dateness, received high ratings ranging from 88% to 100%. Similarly, the feasibility evaluation by media experts yielded comparable results, with an overall average score of 97% (refer to Table 1).

Table 1. Results of Material Expert Product Feasibility

No	Aspect	Presentation	Criteria
1	Relevance	100%	Highly Valuable
2	Accuracy of Material Structure	100%	Highly Valuable
3	Accuracy of content	100%	Highly Valuable
4	Grammatical Correctness	100%	Highly Valuable
5	Correct spelling, terms and punctuation	100%	Highly Valuable
6	The level of difficulty of the material with the user	88%	Highly Valuable
7	Update of materials	94%	Highly Valuable
	Total	97%	Highly Valuable

Based on the table, it can be seen that the material expert test has 6 aspects, namely: a. relevance, b. accuracy of the material structure, c.accuracycontent of the material, d. grammatical correctness, e. Correctness of spelling, terms, and punctuation, f. Level of difficulty of the material with the user, g. The timeliness of the material. Relevance obtains a percentage of 100% so that it has valid criteria. The accuracy of the material structure has a percentage of 100% so that it has valid criteria. The accuracy of the material content has a percentage of 100% so that it has valid criteria. The correctness of grammar has a percentage of 100% so that it has valid criteria. The correctness of spelling, terms, and punctuation has a criterion of 100% so that it has valid criteria. The level of difficulty of the material has a percentage of 88% so that it has valid criteria. The timeliness of the material has a percentage of 94% so that it has valid criteria.

Overall, the evaluation from the material experts has valid criteria so that the media developed does not need to be revised and can be used for further testing.

Table 2. Media Expert Product Feasibility Results

No	Aspect	Presentation	Criteria
1	Substance	96%	Highly Valuable
2	Color	100%	Highly Valuable
3	Uses of media	90%	Highly Valuable
4	Illustration image/Animation/Video	100%	Highly Valuable
5	Letter	94%	Highly Valuable
6	Navigation	100%	Highly Valuable
	Total	97%	Highly Valuable

Table 1 and Table 2 show the results that the product has met the validation standards in terms of materials and media, so it does not require significant revisions before conducting practicality and effectiveness tests.

The practicality of the teaching materials was assessed through teacher and student questionnaires. Based on the data in Table 3 and Table 4, the practicality of the product obtained an average of 96.99% from teacher responses and 90.28% from individual student responses, as well as 92.43% in the small group test (Table 5). All of these results indicate a very practical category.

Table 3. Results of the Teacher Response LKS Questionnaire

No	Aspect	Presentation	Criteria
1	Benefit	93.75	Very Practical
2	Presentation	97.22	Very Practical
3	Appearance	100	Very Practical
4	Presentation of practicality	96.99	Very Practical

Table 4. Results of the Individual Student Response LKS Questionnaire

No	Aspect	Respondents			Amount	Percentage	Criteria
		1	2	3			
1	Appearance	3.50	3.50	3.25	10.25	85.25%	Very Practical
2	Presentation of Material	3.88	3.13	3.56	10.56	88.06%	Very Practical
3	Learning Activities	3.72	3.28	3.89	10.89	90.77%	Very Practical
4	Question	3.43	3.57	3.97	10.97	91.44%	Very Practical
5	User feelings	3.61	3.89	3.99	11.49	95.86%	Very Practical
	Average percentage of practicality	3.63	3.47	3.73	10.83	90.28%	Very Practical

Table 5. Results of the Student Response LKS Questionnaire for Small Group Tests

No	Aspect	Respondents							Amount	Percentage	Criteria
		1	2	3	4	5	6	7			
1	Appearance	3.50	3.50	3.50	3.75	3.75	3.75	4.00	25.75	92.00%	Very Practical
2	Presentation of Material	3.63	3.63	3.63	3.94	3.69	3.44	3.75	25.69	91.75%	Very Practical
3	Learning Activities	3.41	3.41	3.91	3.98	3.92	3.36	3.69	25.67	91.44%	Very Practical
4	Question	3.60	3.60	3.73	3.75	3.73	3.59	3.92	25.92	92.36%	Very Practical
5	User feelings	3.65	3.65	3.68	3.94	3.93	3.65	3.98	26.48	94.59%	Very Practical
6	Average percentage of practicality	3.55	3.58	3.64	3.84	3.81	3.70	3.85	25.92	92.63%	Very Practical

The results of the effectiveness test showed that 87.5% of students succeeded in achieving learning completion (28 students), with an average score of 92.39% in various aspects such as appearance, presentation of materials, learning activities, and questions (Table 6). This shows that the product is very effective in supporting learning.

Table 6. Field Trial Recapitulation Results

No	Validity Criteria	Amount	Percentage	Criteria
1	Appearance	103	91.52%	Very effective
2	Presentation of Material	103	91.85%	Very effective
3	Learning Activities	103	92.16%	Very effective
4	Question	103	92.01%	Very effective
5	User feelings	106	94.43%	Very effective
6	Average percentage of practicality	103.6	92.39%	Very effective

The initial product revision was conducted following an analysis and evaluation of feedback and suggestions provided by validators, including media experts, material experts, and end-users. The revision process was carried out in three stages: the first stage addressed feedback from material expert validators, the second focused on input from media expert validators, and the third incorporated evaluations from product users, namely teachers and students.Product Revision Phase 1. This revision was made based on the assessment conducted by material experts. The suggestions given can be presented through the following table.

Table 7. Suggestions and Revisions from Material Experts

No	Suggestion	Revision
1.	Not all students have a visual character, so the media needs to be revised.	Revise text material to make it more concise
Overall comments		
1.	In general, it meets the requirements for digital thematic teaching materials (multimedia) in terms of the accuracy of the material.	

The second revision is based on the assessment of media experts. The suggestions from media experts can be presented in the following table.

Table 8. Media Expert Suggestions and Revisions

No	Suggestion	Revision
1	The color of the front writing is too blue so it is less attractive.	Replace the text with the appropriate color
2	The choice of animal between rats and eagles is still big rat	Reduce the size of the mouse
3	The sound is not audible so it needs to be turned up when in the middle of media playback.	Increase the volume of sounds that are still not audible
Overall comments		
3	In general, it meets the criteria for suitable teaching materials, but some improvements are needed to perfect the product.	

The third revision is based on user assessment. The suggestions from users can be presented through the following table.

Table 9. Suggestions and Feedback from Users

No	Suggestion	Revision
1.	The background for teaching materials should be made more varied in color.	Create more varied colors on the background.
Comment		
3.	It would be better if the material was clarified at each meeting.	The teacher divides the media into 6 meetings so that it is complete in the competencies learned in one theme.

Based on the evaluation of material experts, Pop Es media obtained a percentage of 94% so that it has the criteria to be suitable for use without revision with a very good category.

A preliminary study at SDN Tasikmadu 1 was conducted at the beginning of the research and development. Based on the analysis conducted, the researcher will develop POP Es media that will be used inlearningthematic in grade 5 of elementary school. The selection of media is based on the characteristics of grade 5 elementary school students who have experienced cognitive development from concrete to abstract so that the media can be relevant to use. The second reason is that the school has a computer lab that is used for student exams, both AKM for grade 5 and UKD for grade 6, so that the number of computers in the school is sufficient for students to useclass5 in using the developed media. The third reason is the availability of internet network in schools which is used as a supporting facility for media development.

The creation of guided inquiry-based teaching materials aligns with constructivist learning theory, which prioritizes active student participation in the learning process. The scientific steps of observing, questioning, reasoning, and communicating employed in this approach are consistent with the framework proposed by Sund and Trowbridge (1973). Findings from this study demonstrate that the application of the developed interactive media effectively enhances both student engagement and learning outcomes.Study Based on Due Diligence by Media Experts. The development of Pop Es media was tested for its feasibility by media experts with an average percentage of 96.59%.so thathas valid criteria. Based on the existing percentage, the media does not need to be revised before the field test is carried out.

Field Trial Based Study, ResultsevaluationField testing includes evaluations from teachers and students as users. Based on teacher evaluation. Study Based on Related Research, The development of Pop Es media has been tested for validity, effectiveness and practicality so that it is suitable for use in learning.

The results from the teacher and student response questionnaires reveal that the LKS teaching materials developed for this study are considered "Very Practical" by both teachers and students. The teacher response questionnaire (Table 3) shows high practicality ratings across all aspects, with "Appearance" receiving the highest rating at 100%, followed by

"Presentation" at 97.22%, and "Benefit" at 93.75%. The overall presentation of practicality is rated at 96.99%, suggesting that the materials are highly valued by educators for their effectiveness and usability.

Similarly, the individual student response questionnaire (Table 4) also demonstrates strong approval of the LKS materials. Students rated the materials' practicality across different aspects, with the highest scores for "User feelings" (95.86%) and "Question" (91.44%), contributing to an overall average practicality rating of 90.28%. These results indicate that students found the materials engaging and beneficial for their learning process, which reflects the positive impact of the inquiry-based multimedia approach.

Finally, the small group test (Table 5) further confirms the practicality of the materials. With an overall average practicality rating of 92.63%, students once again rated aspects like "User feelings" and "Appearance" highly, emphasizing the engaging and user-friendly nature of the LKS materials. These findings suggest that the integration of multimedia and guided inquiry effectively enhances student motivation and involvement in learning, providing a promising approach to improving science education in elementary schools.

The results of this study are consistent with the findings of Agustina (2016) and Widani et al. (2019), which show that the use of multimedia-based teaching materials and guided inquiry can improve students' understanding of scientific concepts and attitudes. Compared to Afifah's research (2015), this product has advantages in visual presentation and animation, so it attracts students' attention more.

The results of practicality and effectiveness show that this product can be a solution in improving student motivation and learning outcomes, especially in scientific-based thematic learning. Revisions based on validator and user input have ensured that this product is relevant to the needs of fifth grade students.

Conclusion

This study successfully developed interactive multimedia inquiry-based teaching materials for the ecosystem theme of fifth grade elementary school students using the Lee and Owens development model. The resulting product has met the criteria of validity, practicality, and effectiveness based on evaluations from experts, teachers, and students. The validation results showed a validity level of 97% for material experts and media experts, so this teaching material is very suitable for use. The level of practicality reached an average of 91% based on teacher and student responses, making it a very practical open material. The effectiveness of the teaching material was also tested with the achievement of student learning completion of 87.50%.

This teaching material has been proven to be able to increase student motivation, activity, and learning outcomes. However, several improvements, such as improving visual materials and presentation structures, are recommended for further development so that this product is more effective and attractive. Dissemination of teaching materials can be done through KKG activities, seminars, and journal publications so that its use is wider. Thus, this teaching material is expected to be an effective guide for teachers in improving the quality of science-based thematic learning in elementary schools.

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