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Development of a Metacognition-Based E-Book Using 3D Pageflip to Enhance Polymer Chemistry Literacy in Coordination Polymerization Reactions

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ABSTRACT

The development of a metacognition-based e-book using 3D Pageflip on coordination polymerization reaction materials aims to enhance students' polymer chemistry literacy. The Polymer course in the Chemistry Education Study Program covers various polymerization reactions essential for students in today's educational era. Polymers, including plastics, Styrofoam, nylon, and others, are crucial materials in various aspects of life. Due to the abstract nature of this subject, theoretical explanations are challenging for students to understand. A metacognition-based e-book is expected to assist students in self-learning, increasing flexibility in understanding polymerization reaction materials. This study employs the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) and produces an e-book containing text, animations, videos, and music. Validation by experts indicates that the e-book is excellent in terms of content and design. Implementation among students shows that this e-book is effective in enhancing the understanding of coordination polymerization reactions. Thus, the e-book is expected to facilitate learning and improve students' polymer chemistry literacy.

Keyword: Science literacy, polymer chemistry, polymerization reaction, coordination polymerization.

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INTRODUCTION

The quality of a nation's progress is significantly influenced by the literacy levels of its students and workforce. One supporting factor is scientific literacy, which has become a critical issue over the past few decades, making students aware of the benefits of literacy, and has become a primary goal for educators, scientists, and curriculum policymakers (Hernandez, Martinez & Irene, 2015). Based on this idea, Roberts (1983) suggested that science education should be directed towards developing literacy among students to prepare them to become global citizens. The National Institute for Literacy (1992) defines literacy as the ability of individuals to read,

write, speak, calculate, and solve problems according to the skill levels required in work, family, and society. According to UNESCO, literacy is an essential right in education. Fulfilling this right enables everyone to access science, knowledge, technology, and legal regulations, as well as to utilize cultural wealth and media effectively. Based on these definitions, literacy can be seen as an individual's ability to acquire, learn, and use all useful information in their life's journey, as part of developing their quality and potential.

Metacognition is one of the core competencies in higher education curricula. The curriculum requires students to understand, apply, and explain metacognitive knowledge in science, technology, arts, culture, and humanities. According to metacognition theory, students who learn possess specific skills to organize and control what they learn. These skills vary among individuals based on their thinking processes. The four types of skills are problem-solving, decision-making, critical thinking, and creative thinking. Creative thinking skills involve using one's thinking processes to generate new, constructive, and good ideas based on rational concepts and principles, as well as perceptions and intuition.

The latest results from the Program for International Student Assessment (PISA), which aims to periodically assess students' and learners' literacy in reading, mathematics, and science, place Indonesia in the bottom ten rankings. However, efforts are being made to improve this situation, such as curriculum reforms initiated by the government.

According to James Rutherford, scientific literacy refers to all forms of literacy related to science, while scientific literacy is a form of literacy that refers to all subject disciplines, such as language, social sciences, and science (Robert, 2008). In this study, the scientific literacy being developed is the students' polymer chemistry literacy on polymerization reaction materials. Aspects of polymer chemistry literacy according to Shwartz, Ben-Zwi & Hofstein (2006) include:

1. Explaining phenomena using polymer chemistry concepts
   Recognizing the importance of chemical knowledge in explaining everyday phenomena. Understanding the theory, models, and concepts of polymer chemistry, which cover a wide and deep application.

2. Using polymer chemistry understanding to solve problems
   Applying knowledge of polymer chemistry in daily life as consumers of new products and technologies, making decisions, and participating in social debates on chemistry-related issues. Understanding how polymer chemistry science and technology are interconnected. Polymer chemistry science aims to produce explanations about nature, while polymer chemistry technology seeks to change the world itself. The models and concepts generated by both fields are strongly interconnected, influencing each other.

3. Analyzing strategies and benefits of polymer chemistry applications
   Understanding the relationship between innovation in polymer chemistry

processes and social life (importance of applications such as medicines, fertilizers, natural and synthetic polymers). Appreciating the impact of polymer chemistry science and technology on society. Understanding the nature of prevailing polymer chemistry phenomena. Generating changes or variations in a phenomenon by changing the world we see or looking from a different perspective.

One way to continuously help students develop polymer chemistry literacy in polymerization reaction materials is by applying several learning approaches or models and developing learning media, questions, and evaluation instruments that can improve students' polymer chemistry literacy in polymerization reaction materials. To determine the development of students' polymer chemistry literacy in polymerization reaction materials, it is necessary first to know the literacy skills they already possess. Therefore, to enhance the scientific literacy skills of Chemistry Education students at Jambi University, research on the "Development of a Metacognition-Based E-Book Using 3D Pageflip for Coordination Polymerization Reaction Materials" is necessary.

METHODS

Location and Time

The research was conducted in the Chemistry Education Study Program at the Faculty of Teacher Training and Education (FKIP) at Universitas Jambi. The study took place in the Basic Chemistry Laboratory of PMIPA FKIP Universitas Jambi and the Computer and Programming Laboratory of the Chemistry Education Study Program at FKIP Universitas Jambi. The teaching of Polymer Chemistry for the Polymerization Reaction material was carried out with students of the Chemistry Education Study Program in the fifth semester at FKIP Universitas Jambi during the odd semester of the 2021/2022 academic year. The time required from the preparation of the research to the writing of the report, involving all members of the research team, was approximately six months.

Population and Sample

The population in this teaching includes 30 students from the fifth semester of the Chemistry Education Study Program. The sample consists of all the students mentioned above, meaning that the sample was taken from the entire population enrolled in this course.

Tools and Materials

The tools used in this research include common items such as paper, pens, special whiteboard markers, a projector, a digital camera, a handy Cam, and a computer equipped with 3D Pageflip, ISIS Draw, Chem Office, and Macromedia Flash programs. The materials for teaching include an outline of the main topics in the Polymer Chemistry course, Polymer Chemistry books, and the Addition Polymerization Reaction material already in the form of learning media using computer-assisted learning applications specifically for Coordination Polymerization Reaction material.

Development Model

The development design in this research uses the ADDIE development model. This model was chosen because the development product is computer-based

learning media, which requires clear and descriptive steps. The development steps according to ADDIE are analysis, design, development, implementation, and evaluation.

Development Procedure

The development procedure consists of five stages: analysis, design, development, implementation, and evaluation, which are explained in the following points:

1. **Analysis.** During the analysis stage, several factors must be considered in the development process: needs analysis, student characteristics analysis, material analysis, and educational technology analysis.
2. **Design.** Before creating the learning media, a draft of the learning media is created based on the information and data collected in the previous stage. This draft is used to create a flowchart or diagram of the learning media, serving as a foundation for creating the media. Subsequently, a storyboard is created from the flowchart or diagram, which will eventually form the basis for developing the learning media.
3. **Development.** After designing, the media is developed. The researcher uses 3D Pageflip software to develop the learning media for addition polymerization reactions. The product will be in the form of an e-book learning media for addition polymerization reactions using 3D Pageflip software, containing text, animations, videos, and background music. Once the product is completed, it is validated by two expert teams, consisting of subject matter experts and media experts, to assess its feasibility. Validation is conducted multiple times to ensure the product is truly deemed suitable.
4. **Implementation.** Implementation is the concrete step of applying the learning system that has been created. At this stage, everything developed is installed or set up according to its role or function to be implemented. The product that has been revised by the expert team and deemed suitable will be tested on a small group of about 10 students.
5. **Evaluation.** The evaluation conducted is formative, aimed at revising or improving and gathering suggestions from media experts and subject matter experts at the four stages above.

Data Types

In this developmental research, both qualitative and quantitative data are collected. During the validation and product evaluation stages, the qualitative data gathered includes feedback, comments, criticism, and suggestions from subject matter experts and media experts, as well as student responses to the improvement of the learning media. Quantitative data consists of numbers or scores obtained from the assessments by media experts, subject matter experts, and student responses to the metacognition-based Coordination Polymerization Reaction e-book using 3D Pageflip.

Instruments

The instrument used in this research is a questionnaire utilizing a Likert scale, administered to experts for validation (media experts and subject matter experts) and student responses.

Data Analysis Techniques

Once data is collected, it will be analyzed. The data obtained in this research includes both qualitative and quantitative data. Qualitative data, in the form of

validation sheets from experts containing feedback, suggestions, and inputs, will be analyzed. Quantitative data, consisting of assessments of product development obtained from student response questionnaires, will be analyzed and processed descriptively into interval data using the Likert scale.

RESULTS AND DISCUSSION

In this study, the development model used for the metacognition-based e-Book on Coordination Polymerization Reactions utilizing 3D Pageflip is the ADDIE model, which consists of the stages: i) Analysis, ii) Design, iii) Development, iv) Implementation, and v) Evaluation.

Validation Results

The validation results from subject matter experts and media experts were categorized into two aspects: content/material aspect and e-book design aspect. Both aspects received "very good" ratings from the expert teams.

Table 1. Quality of e-Book Prototype Based on 3D Pageflip (Second Validation Results)

Evaluation Aspect	Average Score	Expert 1	Expert 2	Overall Rating
Image and Color Aspect	448	446	447	Very Good
Video and Animation Aspect	448	446	447	Very Good
Overall Average	**448**	**446**	**447**	**Very Good**

Table 2. Quality of Content in e-Book Using 3D Pageflip (Second Validation Results)

Evaluation Aspect	Average Score	Expert 1	Expert 2	Overall Rating
Learning Aspect	447	445	446	Very Good
Content/Material Aspect	445	447	446	Very Good
Overall Average	**446**	**446**	**446**	**Very Good**

Overall, the subject matter experts and media experts concluded that the e-book can significantly aid students in understanding the Coordination Polymerization Reaction material. The e-book, as a new teaching material, helps bridge the gap in students' comprehension and facilitates efficient use of learning time.

Delphi Study Validation

Based on the validation questionnaire given to design experts and practitioners, the results are summarized in Table 3.

Table 3. Second Stage Validation Results

Description	Expert I	Expert II
After revision, do the components of the Coordination Polymerization Reaction e-book cover all factors to enhance student understanding?	The components presented are clear enough.	The components of the Coordination Polymerization Reaction e-book are adequate to enhance student understanding. Consider detailing each aspect more thoroughly and operationally. Add more learning facts related to Coordination Polymerization Reaction.
Theoretically, will the components of the Learning Design Model for Coordination Polymerization Reaction enhance student understanding?	The theory used is sufficient.	The learning model for Coordination Polymerization Reaction will enhance student understanding by engaging them in macroscopic, microscopic, and symbolic representations of chemistry. Care must be taken to avoid conceptual errors when representing microscopically through computer animations.
Does the e-book learning design model make it easier for users, both beginners and experts?	The e-book design model will be easier if all concepts are accompanied by examples.	The components of the Coordination Polymerization Reaction e-book design model are easy to guide users who want to develop in the same field. However, the philosophical explanation should be added.
Does the revised e-book learning design model reduce the interpretation gap between beginners and experts?	OK.	The interpretation gap can be reduced by detailing the reasons for developing the e-book model, why this model was chosen, the main differences from adopted models, and the advantages of the developed Coordination Polymerization Reaction e-book model.
Does each component of the e-book Coordination Polymerization Reaction have the potential to enhance student understanding?	The potential to enhance understanding is higher if each concept includes the material to be delivered.	Each component's function has the potential to enhance student understanding. Adding an explanation of the role of needs analysis in developing the learning design model directly on Coordination Polymerization Reaction material is suggested.
Which parts of the learning design model need revision?	The application of the e-book design model.	It would be better if the learning concepts are fully included, with macroscopic, microscopic, and symbolic examples. In the "learner needs analysis" component, additional explanations on the relation of motivation to the developed learning model are required. Why motivation analysis is needed, and its role in concluding to develop the learning model for Coordination Polymerization Reaction. The learning objectives should show the development of higher-order thinking skills (HOTs C4–C6), not just C1–C3. Consistent use of terms like students, learners, and pupils within the book is recommended.

After validation, it was suggested to make the e-book clearer and more detailed, making it easier for instructors and students to use in classroom learning. The cover design should be made more attractive and focused.

Figure 1. Example Contents of the Coordination Polymerization Reaction e-Book

CONCLUSION

The metacognition-based e-book on Coordination Polymerization Reaction using 3D Pageflip enhances individual students' abilities and stimulates interest, thus motivating students to improve their academic performance and learning outcomes. This e-book also bridges the gap in students' comprehension during classroom learning, allowing for individualized treatment and addressing the issue of low student self-actualization. The developed e-book enables students to explore the material further, ensuring a comprehensive understanding of the

Coordination Polymerization Reaction. The results of this study include a metacognition-based Coordination Polymerization Reaction e-book using 3D Pageflip that aligns with the current curriculum and educational principles, containing educational elements.

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