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Development of E-Module for Electrolyte and Nonelectrolyte Solution Based on Problem Based Learning Integrated with STEAM for SMA/MA

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A B S T R A C T

Students have difficulty understanding electrolyte and nonelectrolyte solution materials, because they are required to understand three representations including symbolic, macroscopic, and submicroscopic. With e-module, it can increase students' interest in learning and e-module is designed so that students can study material independently and actively. This study aims to produce e-modules of electrolyte and nonelectrolyte solutions based on steam integrated problem-based learning for SMA / MA to analyze the validity and practicality of the e-module. This study is 4D development model. E-module validity test was carried out by 3 lecturers of FMIPA an FT UNP, and 2 chemistry teachers. Practicality test was carried out by 2 chemistry teachers and 30 students of class XI of SMAN 1 Payakumbuh. Validity questionnaires were analyzed using the Aikens'V formula and practicality questionnaires were analyzed using descriptive statistical percentages. From results of the study, average score of Aikens'V was obtained at 0.97 with a valid category. Practicality value of e-modules obtained is 98%, 96% respectively with practical category. Based on results, can be concluded e-module is valid and practical. Therefore, this research can be continued to stage of effectiveness testing, so that this e-module can be used in the learning process.

1. Introduction

In order to overcome learning loss, there is a need for a learning recovery policy within a period of time related to curriculum implementation by the teaching unit. For this reason, the Ministry of Education and Culture has developed its own curriculum as an important part of its efforts to learn lessons from crises. An independent curriculum is one that has different learning content within the curriculum where the content is more optimal, giving students ample time to

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explore concepts and strengthen their competencies. There are several learning models that can support independent curriculum implementation, including project-based learning, problem-based learning, discovery learning, and collaborative learning models (Kemendikbud, 2021) .

According to (Alfiantara et al., 2016) , problem-based learning (PBL) exposes students to real-life problems. The more a learner has experience with problems, the more effective thinking and skills to build thinking to solve these problems will increase. This model results in students finding new knowledge through solving problems (Savery, 2006) . Long-term learning and mastery is the goal of PBL rather than just conceptual understanding (Brownell & Jameson, 2004) .

STEAM is one of the 21st century learning alternatives . The application of STEAM in learning activities includes 4C namely creativity, critical thinking, collaboration and communication, so that students can find creative solutions to real-life problems and are able to communicate them well (Lestari et al., 2018) . STEAM has a number of features, including technology -based, performance-based, inquiry-based, and problem-based learning (ITEA, 2009; Chi, H., and Jain, H., 2011).

Chemistry is part of learning science which is ideally carried out in accordance with emphasizing the process of observing, predicting, classifying, concluding, and communicating so that students are required to play an active role in learning to find solutions to a problem. In general, students have difficulty understanding elnoel solution material, because they are required to understand three representations including symbolic, macroscopic, and submicroscopic (Aulia & Andromeda, 2019) . However, at school it only shows the macroscopic and symbolic levels so that students' understanding is limited (Harianto, et al. 2019). Not only that, the availability of teaching materials is not able to explain related to the submicroscopic level so that students cannot understand and link the three representations which results in low student learning outcomes at the submicroscopic level questions (Putra, et al. 2017). One of the teaching materials that can be applied by educators is a module because it does not require exclusive equipment and high abilities. The material for electrolyte and non-electrolyte solutions is abstract material , so that it will make it easier for students to complete the learning process with assistive devices, one of which is a module (Asyhar, 2021). Without the ability to construct different learning materials, educators will fall into a monotonous process and tend to saturate students (Hamdani, 2011).

With advances in technology in the 21st century, modules that were originally designed in printed form can now be presented in electronic form, also known as e-modules. E-modules are learning modules that are created using technology and communication, contain text, images, along with simulations that are usable and appropriate to use and can be read anytime and anywhere (Herawati & Muhtadi, 2018) . E-module is a learning guide that helps students improve their learning outcomes and emphasizes the importance of active student participation (Suryadi, 2014). With the e-module, it is hoped that it can increase students' interest in learning because the learning material presented in the e-module is structured and designed to be more attractive by adding animation, learning videos, or audio and the e-module is designed so that students can learn the material effectively. independent and active. Based on research conducted by Priscylio (2019), the problem-based learning worksheets have very high validity and practicality, and these findings also show that developed student worksheets can increase students' interest in learning and can help students to learn independently.

Based on the results of observations that have been made by giving questionnaires to 3 chemistry teachers for class X SMA/MA, namely 2 chemistry teachers at SMAN 1 Payakumbuh and 1 chemistry teacher at SMAN 10 Padang and 50 students in class X MIPA at SMAN 1 Payakumbuh, it was found that: (a) 49.2% of students considered chemical material, especially electrolyte and non-electrolyte solutions to be difficult to understand and 35.8% of students considered material for electrolyte and non-electrolyte solutions to be quite difficult to understand, (b) according to 50.1% of participants students find it difficult to understand electrolyte and non-electrolyte solution material due to the lack of availability of teaching materials that attract students' interest then 56.6% of students consider electrolyte and non-electrolyte solution material to have abstract properties, (c) 85% of teaching materials used by students to study chemistry, especially electrolyte and non-electrolyte solution materials, are still in the form of printed teaching materials, (d) 77.4% of students consider the available teaching materials has not increased the enthusiasm for learning, especially in the material of electrolyte and non-electrolyte solutions to the fullest. This study aims to produce e-modules of electrolyte and non-electrolyte solutions based on STEAM integrated problem-based learning for SMA/MA that are valid and practical.

2. Methodology

The type of research used is Research and Development (R&D) or commonly called development research . Development research is research that produces a product and tests the effectiveness of the resulting product. The development model used in this study is the 4-D development model (Sugiyono, 2017). The subjects of this study were lecturers in the chemistry department at FMIPA UNP, high school chemistry teachers, and class X students at SMAN 1 Payakumbuh . The data used in this research is primary data. Primary data is data that is directly obtained from giving validity and practicality questionnaires to research subjects. The instrument used to collect data in this study was a questionnaire, namely a questionnaire to test the validity and practicality test. The validity test was carried out by 5 validators while the practicality test was carried out to students and teachers in 1 meeting . The two questionnaires were prepared based on a modified Likert scale from Riduwan (2012). The data analysis technique used to analyze the validator's assessment is by using the Aiken's V formula . Practicality data were obtained from practicality questionnaires filled out by teachers and students and then processed using quantitative descriptive analysis.

3. Results and Discussion

The products resulting from the research that has been conducted are e-modules of electrolyte and non-electrolyte solutions based on STEAM integrated problem-based learning for SMA/MA. Then validation of the e-module was carried out for lecturers and chemistry teachers. This study uses the first 3 stages of the 4-D development model which consists of define, design, and development , with the results described as follows.

Stage Define

At this stage, five steps of analysis were carried out, namely front end analysis, student analysis, task analysis, concept analysis and learning objectives analysis. The results of these stages are as follows:

a) Front-end analysis

This is done in order to find out the problems that exist in the field and the condition of teaching materials in the form of e-modules in learning activities. Analysis by filling out a questionnaire by 2 chemistry teachers at SMAN 1 Payakumbuh and distributing questionnaires to 50 students at SMAN 1 Payakumbuh.

Based on the results of a questionnaire from two chemistry teachers, it is known that (1) the most lacking in the module used by the teacher is the absence of supporting animation and the lack of percentage of movement from students, (2) when given a module, there are still many students who do not respond to the module given (3) even in the implementation of learning, students are still constrained by internet networks and constrained by internet packages. Then based on the results of the questionnaire distributed to the students it can be seen that (1) in learning, the teacher has used a variety of learning media even though not all students have them, (2) the material is part of electrolyte and non-electrolyte solutions which students find difficult because the material is abstract and using various representations, namely symbolic, macroscopic and submicroscopic.

b) Student analysis (learner analysis)

Based on the questionnaire distributed, it is known that students have been able to fulfill the KKM (Minimum Passing Criteria) but in the learning process students are still not actively involved. Then there are students who are still constrained in the internet network when learning is done online.

c) Task analysis

analysis is carried out to determine the content of the material and competencies that must be achieved in learning. The preparation of e-modules refers to learning outcomes (CP) and learning objectives (ATP) in the independent curriculum. Based on the learning outcomes, the learning objectives flow is obtained, namely analyzing the electrical conductivity properties of a solution in everyday life

d) Concept analysis

Concept analysis is obtained by tabulating important concepts in the material of electrolyte and non-electrolyte solutions so that concept labels, concept definitions, types of concepts, attributes, factual concept positions, and principles are known. The concept analysis is compiled into a concept map.

e) Analysis of Learning Objectives

In this analysis stage, the formulation of learning objectives is carried out based on the flow of learning objectives that have been previously formulated on the material of electrolyte and non-electrolyte solutions.

Design Stage

At this stage, the media is determined according to the learning objectives, chooses a format and an initial design is carried out for the development of the electronic module. The e-module is designed based on the module writing format provided by the Ministry of Education and Culture guidelines (2017) which has been modified.

Stage Development

At this stage the results of the validity and practicality test of the electrolyte and non-electrolyte solution e-module based on STEAM integrated *problem-based learning* were given by UNP chemistry lecturers, UNP engineering lecturers, chemistry teachers at SMAN 1 Payakumbuh, and students at SMAN 1 Payakumbuh. This stage consists of three steps, namely validity test, revision and practicality test. The quality of the results of a product being developed can be seen from three criteria, namely validity, practicality, and effectiveness (Rochmad, 2012). The following is a description of each step.

a) Validity Test

The validity test consists of four components, namely content feasibility, component language, component presentation And component graphics. The validity test questionnaire was prepared based on modifications from the Ministry of National Education (2008). Validation was carried out by two chemistry lecturers from FMIPA UNP, one UNP engineering lecturer, and two chemistry teachers from SMAN 1 Payakumbuh. The results of the analysis of the validity of the module data obtained from five people validator could seen on Table.

Table 1. Validity Data Analysis Results

Rated aspect	V grade	Validity category
Content Eligibility	1.00	Very high
Serving Components	0.96	Very high
Language Component	0.97	Very high
Graphical Components	0.95	Very high
Total V score	0.97	Very high

Based on Table obtained score the average value of Aiken's V for all aspects assessed in the module is 0.97 with category validity very tall. Average value Aiken's V against content feasibility assessment is equal to 1.00 with the category of validity very tall. Average value Aiken's V against component assessment presentation is 0.96 with a very high validity category. Average score Aiken's V against evaluation component language is 0.97 with a very high validity category. Average score Aiken's V on the assessment of the graphical component is equal to 0.95 with category validity very high.

b) Revision

The revision stage aims to improve the electrolyte and non-electrolyte solutions based on STEAM's integrated problem-based learning considered Still not enough appropriate by validator before product tested. Revision is complete when the e-module being developed is declared valid by the validator. Comparison of the display of electrolyte and non-electrolyte solution based e-modules based on STEAM integrated problem-based learning before and after revisions based on input and suggestions from the validator are described as following:

1) Cover E-Modul

Based on input and suggestion from mentor and validator then the e-module cover was revised by changing the image design and background color on the e-module cover display, this done so that the appearance of the cover is more attractive to students to read e-modules of electrolyte and non electrolyte solutions based on STEAM integrated problem based learning. Comparison appearance cover e- module could seen on Figure 1.

Figure 1. Display of the E-Module Cover Before Revision (Left) and After Revision (Right)

2) Consept Maps

Based on input and suggestion from mentor and validator then the connecting words on the concept map are replaced so that students understand more about the relationships between existing concepts. Comparison concept maps could seen on Picture 2.

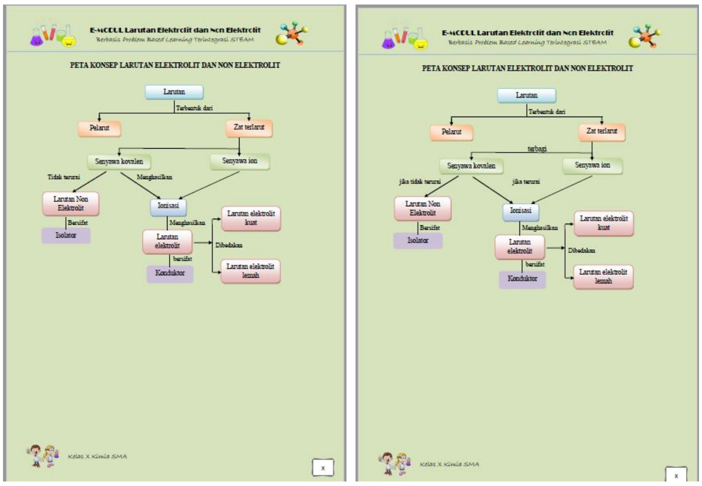

Figure 2. Display of the Concept Map Before Revision (Left) and After Revision (Right)

3) Introduction

Based on input and suggestion from mentor and validator then the problems or cases that exist in the introduction section are more clearly related to the material of electrolyte and non-electrolyte solutions and a clear source is included in the narrative. Comparison introduction could seen on Picture 3.

Figure 3. Preliminary Display Before Revision (Left) and After Revision (Right)

4) Conclusion

Based on input and suggestion from mentor and validator then in the conclusion section on the activity sheet a revision is made, namely by making the conclusion section a button and connected to the *Google form* . So that students can be actively involved in the learning process and can be supervised by the teacher. Comparison introduction could seen on Picture 4.

Figure 4. Display of Conclusions Before Revision (Left) and After Revision (Right)

5) Question Variations

Based on input and suggestion from mentor and validator then some questions are varied so that the teacher can see how far the students' understanding of the material is good. Comparison varied questions could seen on Picture 5.

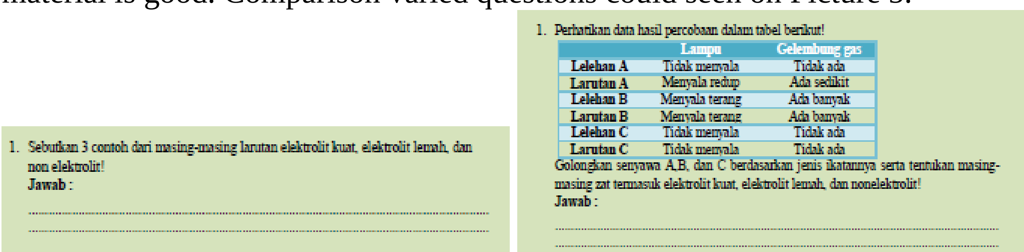

Figure 5. Comparison of Questions Before Revision (Left) and After Revision (Right)

c) Practicality Test

Problem-based learning electrolyte and non-electrolyte solution e-module can be seen from the use of the products from field trials regarding the practicality and applicability of the products being developed. Practicality data was obtained from the results of the analysis of the response questionnaire of 2 chemistry teachers at SMAN 1 Payakumbuh and the response questionnaire of 30 students at SMAN 1 Payakumbuh. Following data analysis results the practicality of the e-module from the teacher and learners.

1) Test practicality by Teacher

Practicality test it consists of three components that is convenience use, learning activities, and benefits. The practicals were carried out by two chemistry teachers from SMAN 1 Payakumbuh. The results of the analysis of e-module practicality data obtained from one people Teacher could seen on Table 2.

Table 2. Results of E-Module Practicality Data Analysis by Teachers

Rated aspect	P value	Practicality category
User Ease	100%	Very high
Learning Activities	98%	Very high
Benefit	98%	Very high
Total P-value	98%	Very high

Based on Table 2, the average practicality value is obtained of all aspects assessed in the e-module by 98% with very high category. Average practicality value on assessment ease of use is 100% in the very category tall. Average practicality value on the assessment of learning activities is as big 98% with category very tall. Average practicality value on benefit assessment is as big 98% with category very high.

2) Test practicality by learners

Practicality test it consists of three components that is convenience use, learning activities, and benefits. The practicals were carried out by 30 students of SMAN 1 Payakumbuh from class XI MIPA 2. The results of the analysis of the practicality of the e-module data obtained from 30 people student could seen on Table 3.

Table 3. Results of E-Module Practicality Data Analysis by Students

Rated aspect	P value	Practicality category
User Ease	96%	Very high
Learning Activities	96%	Very high
Benefit	96%	Very high
Total P-value	96%	Very high

Based on Table 3, the average practicality value is obtained of all aspects assessed in the e-module by 96% with very high category. Rating of ease of use produces an average practical value 96% with very high category. Assessment of learning activities produces an average value of practicality by 96% very high category. Evaluation to benefit produces an average practical value 96% with very high category.

4. Conclusion

Based on the results of research and data analysis, the following conclusions are obtained:

1. E-modules for electrolyte and non-electrolyte solutions based on STEAM integrated problem-based learning for SMA/MA using the 4D development model have been developed.
2. The developed E-Module for electrolyte and non-electrolyte solutions is declared valid with a high validity category and is declared practical with a very practical product category.

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