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Development of STEM-PjBL Based E-Modules on Acid-Base Material to Improve Learning Outcomes

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Abstract: This study aims to determine the needs analysis, validity practicality, effectiveness and student response to STEM-PjBL-based E Modules. This research was conducted at SMAS Kartika I-2 Medan and th sample of class XI IPA 2. The type of research used is Research an Development (R&D) and the development model is 4-D (Four D). The dat collection technique is through interviews, observations, questionnaires an tests. Data analysis on the validity test uses the kappa moment formula an the effectiveness test uses the N-Gain test. The results obtained are analyzin the needs of teachers have not maximally used the PjBL learning model, an have never used STEM-PjBL-based E-Modules and the books used have no contained projects and STEM. As many as 69.7% of students feel bored an 57.6% of students prefer to do project-based learning. Validity obtained a average kappa moment of 0.82 very high category, from material experts 0.8 and media experts 0.79 very high category. Practicality by teachers obtaine an average kappa moment of 0.99 very high category. Effectiveness obtaine an average N-gain of 0.52 medium category. Student response obtained a average kappa moment of 0.81 very high category.

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Introduction

This 21st century learning leads students to be more active in the learning process, creative and innovative, so that a new innovation is needed in improving students' skills, especially in the fields of science and mathematics. One of the innovative steps that can be taken to increase students' science and mathematics creativity is by combining science and mathematics in a system that is supported by engineering and technology (Aulya, 2021).

Chemistry is one of the sciences and mathematics studied at the high school level. The goal in studying chemistry is for students to be able to master concepts, theories and laws to be able to explain various natural phenomena. Chemistry learning expects students to be able to understand issues related to chemistry found in everyday life, the application of chemistry in technology, and be able to apply chemistry to solve problems in everyday life. Therefore, chemistry is one of the subjects that can be used to develop 21st century skills.

One of the materials in chemistry learning in class XI even semester is acid base. Acid base is one of the materials that requires memorization and understanding and the material requirements related to subsequent materials such as hydrolysis, buffers, and Ksp so that the need for a good and correct understanding of the concept.

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Based on the results of interviews and observations conducted at Kartika 1-2 Medan Private High School with chemistry teachers, it was found that on acid-base material, the learning outcomes of students with an average of 70% were still below the KKM and only 30% had met the learning KKM, where the Minimum Completeness Criteria (KKM) on acid-base material was 78. Students only use learning resources prepared by schools in the form of textbooks which are also not integrated with STEM, and the books used do not do many projects from each sub-chapter on acid-base material. The media that is often used by teachers is like PowerPoint, Teachers have never used E-Modules based on STEM-PjBL in learning chemistry, especially on acid-base materials. Teachers have done learning using the PjBL model but in this learning the teacher has never used a guidebook which is one of the syntaxes of PjBL and the teacher has never combined STEM learning with PjBL.

While the results of the questionnaire given to students in class XII IPA, obtained 69.7% of students feel bored during learning because the media used or the teacher's teaching method is less interesting. As many as 84.8% The learning applied by the teacher is a system of providing material and questions. According to students, interesting books / teaching materials are those that are not monotonous with writing and as many as 57.6% of students prefer to do project-based learning and have never used STEM-PjBL-based E-Modules on acid-base material.

According to Kristiani (2017) STEM-PjBL (Science, Technology, Engineering, and Mathematics - Project Based Learning) is project-based learning with a STEM approach. According to Rosyidah (2021) STEM PjBL is learning in which the process guides students to produce projects. In the process of making projects, an information collection material is needed to monitor the development of students' abilities. Information gathering materials that can be used in this learning process are materials contained in the authentic assessment process. According to Syukri et al (2013) STEM learning has five stages of implementation in the classroom. That is, observation, new ideas, innovation, creativity, community (Amdayani, 2022).

STEM-PjBL is one way to overcome the problems that exist in the results of interviews and observations that have been made. According to Nurhayati (2023) using STEM-based E-Modules with PjBL learning models can improve student learning outcomes. Then, according to Basaroh et al., 2020 and Wibowo & Pratiwi, 2018 from his research said that the Science E-Module using the STEM-PjBL model oriented to character education to improve student learning outcomes was declared valid, practical and effective. And according to research by Amdayani, et al (2022) that STEM-based chemistry modules can improve student learning outcomes in thermochemical material, this is indicated by the average learning outcomes of the experimental class higher than the control class, namely 86.5 and 78.76.

In research by Lutfi et al (2017) said that currently in vogue is STEM-PjBL. Learning outcomes accommodated by science subjects are expected to be actualized through the application of STEM supported by PjBL. Because these learning outcomes intersect with science literacy and creativity, it can also be said that STEM-based learning supported by PjBL is expected to actualize these two competencies. Some research findings state that STEM learning can improve science literacy, creativity, and problem-solving skills (Agung, 2021).

Along with the development of technology and information, the use of E-Modules is one of the options that teachers can choose to help the learning process of students for now (Ismi, 2019 and Seruni et al., 2019). E-Modules are electronic modules which are accessed through electronic devices such as computers, laptops, tablets, or even smartphones (Aryawan et al., 2018; Basaroh et al., 2020; Nopiani et al., 2021). According to Mutmainnah et al., 2021 based on the results of his research using E-Modul was able to improve the learning outcomes of students whose average score of students before using E-Modul was 42.0370 and after using E-

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Modul was 89.6296. According to Dibyantini et al (2023) based on the results of research that the STEM-PjBL integrated chemistry module on organic compound material can improve science literacy and motivation.

Research Method

This research has been conducted at SMA Swasta Kartika I-2 Medan Jalan Brigjen H.A Manaf Lubis, Helvetia Tengah, Kec. Medan Helvetia, Medan City, North Sumatra Province in the even semester of the 2023/2024 school year. The research has been carried out from December 2023 to February 2024.

The population in the study were all students of class XI IPA SMAS Kartika I-2 Medan. The sample used in this study was taken by purposive sampling, namely class XI IPA 2 SMAS Kartika I-2 Medan as many as 33 people with the recommendation of the chemistry teacher who taught directly at SMAS Kartika I-2 Medan.

The type of research used is Research and Development (R&D), namely research and development. The development model used is 4-D (Four D), which is a development model developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel (1974: 5). The 4D development model consists of 4 main stages, namely: Define, Design, Develop and Disseminate.

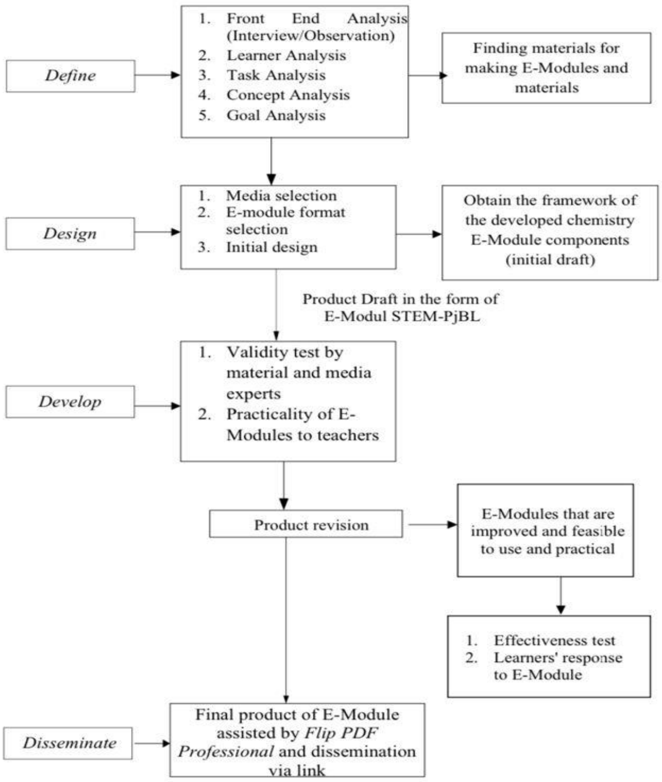

Figure 1 Research Procedures

The research instruments used are interview sheets, observation sheets, student questionnaires, product validation sheets, practicality sheets by teachers, student response questionnaires. Data collection techniques are interviews and angke with stages of interviews, observations, questionnaires, tests. Data analysis in this study is a validity test, practicality test

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and student response using the kappa moment formula and effectiveness test using the N-Gain formula.

Result and Discussion

This research is an R&D development research that produces a product that is valid, practical, and effective, the product is teaching material in the form of STEM-PjBL Based E-Modules on acid-base material. This E-Module development uses the 4D development model from Thiagarajan with 4 stages, namely: (1) define, (2) design, (3) development, (4) desseminate. The following presents the results of the research obtained at each stage of development.

1. Define

At this stage the researcher conducts a defining stage or finding out what are the problems in teaching and learning activities, analyzing students by distributing questionnaires, analyzing the textbooks used and literature study that will be applied to the E-Module by observing the learning process, including variations in learning resources, learning methods used by teachers in the teaching and learning process and to find out the understanding used by teachers in the teaching and learning process to find out the understanding of teachers and students regarding STEM-PjBL.

Based on the interview, it is known that the teacher's teaching and learning process uses the lecture method and the teacher has also used the PjBL learning model but not maximized. The learning media that has been used is powerpoint and has never used STEM-PjBL-based E-Modules and only uses learning resources from textbooks provided by the school. Then, the learning outcomes of students on acid-base material 70% are still below the KKM and only 30% have met the KKM with the Minimum Criteria (KKM) on acid-base material which is 78. At the student analysis stage aims to determine the characteristics of high school students. Based on the questionnaire distributed to students of SMAS Kartika I-2 Medan, it can be concluded that there is no STEM-PjBL-based learning resource. Students consider the subject difficult to understand and boring. So, students need to be equipped with knowledge about project-based chemistry and its relationship with Science, Technology, Engineering and Mathematic so that learning is easier to understand and need teaching materials for students that attract students' reading interest and train students' independence.

2. Design

At the design stage there are 3 things that must be considered, namely: (1) Media selection, media and applications that support the making of E-Modules include: (1) Flip PDF Professional is an interactive media that can easily add various types of animative media types to the flipbook. (2) Canva as a media platform for making graphic design and publication content easier and faster which can be used online via a desktop browser or application download.

(2) Format selection, The presentation format of the developed E-Module is prepared with the help of Microsoft Word with A4 size (21 cm x 29.7 cm) with font type using Times New Roman font with font size 12 pts for all contents except chapter and sub titles. Spacing is 1.5 except for image and table captions with a spacing size of 1.15. The size of the typing margin of each page is 4-3-3-3.

(3) Initial design, in the form of cover, preface and table of contents, introduction, concept map, definition of STEM, material with project-based learning (PjBL) and STEM stages, evaluation questions and answer keys, summary, glossary, bibliography, and author's bio.

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3. Development

Validation Test

The questionnaire sheets used for validity and practicality tests were then interpreted using Cohen's kappa formula (Boslaugh, 2008), with the following formula:

$$\text{Momen kappa (K)} = \frac{Po-Pe}{1-Pe}$$

Assessments that have been analyzed using Cohen's kappa formula can be decided based on the kappa moment with interpretation according to Boslaugh & Walters.

Tabel 1 Decision Category Kappa Moment (K)

Interval	Category
0,81 – 1,00	Very high
0,61 – 0,80	High
0,41 – 0,60	Medium
0,21 – 0,40	Low
0,01 – 0,20	Very low
<0,00	Not valid

(Boslaugh, 2008)

Validation of Questionnaire Instrument

The questionnaire rating on the material expert is 0.97 very high category, on the media expert is 1 very high category, on the teacher's practical questionnaire is 1 very high category, and on the learner response questionnaire is 1 very high category. The average kappa moment of questionnaire validation can be seen in Table 2.

Table 2 Average kappa moment (k) of questionnaire validation assessment

Average kappa moment (k)			
Material expert	Media experts	Practicality by teachers	Learner response
0,97	1	1	1
Rata-rata 0,99 (Sangat Tinggi)			

Based on table 2, the questionnaire that will be used is declared feasible with an average of 0.99 in the very high category. So it is concluded that the questionnaire instrument is ready to be used for research but there are some revisions.

Material Expert Validation

The results of the material expert validator questionnaire assessment of the E-Modul, obtained the kappa moment value of the five aspects of the assessment by each material expert. The results of the kappa moment of the three material expert validators on the STEM-PjBL-based E-Module on acid-base material are in Figure 1.

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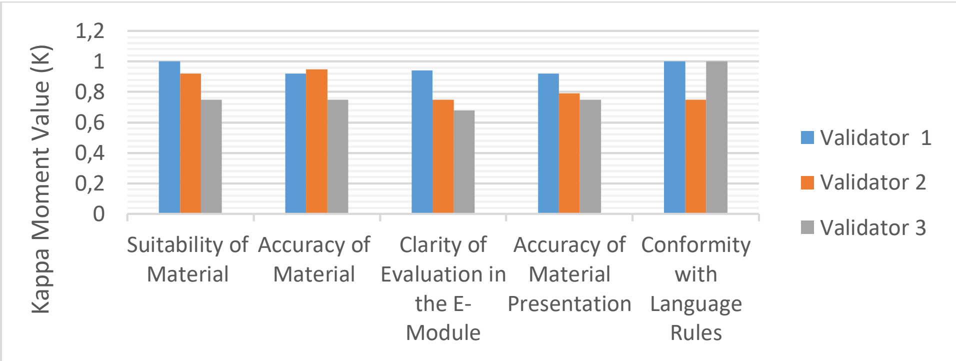

Figure 2 Graph of kappa moments of material experts on E-Modules

On the graph, it can be seen the results of the kappa moment of the assessment of each material expert validator on each aspect. The results of the kappa moment of the three validators on each aspect are: the aspect of curriculum suitability of 0.89, on the aspect of material accuracy of 0.87, on the aspect of clarity of evaluation in E-Modules of 0.79, on the aspect of material presentation accuracy of 0.82 and on the aspect of suitability with language rules of 0.92. Then the average result of the kappa moment of the material expert on the E-Module is 0.86 with the category "Very High".

Media Expert Validation

The results of the material expert validator questionnaire assessment of the E-Modul, obtained the kappa moment value of the five aspects of the assessment by each material expert. The results of the kappa moment of the three material expert validators on the STEM-PjBL-based E-Module on acid-base material are in Figure 2.

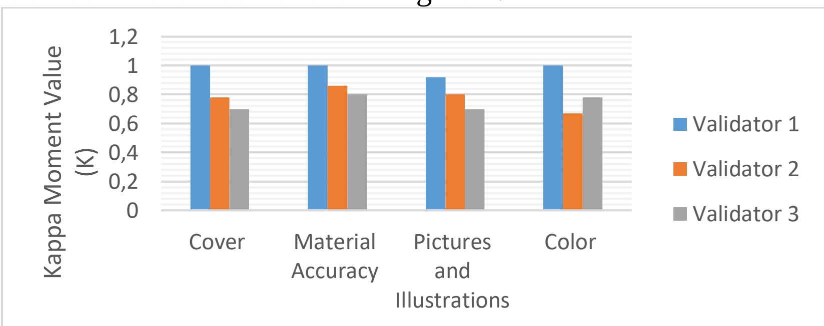

Figure 3 Graph of media expert kappa moments

On the graph, it can be seen the results of the kappa moment of the assessment of each material expert validator on each aspect. The kappa results of the three validators on each aspect are: the cover aspect of 0.72, on the aspect of the accuracy of the material of 0.84, on the aspect of images and illustrations of 0.74, and on the aspect of color of 0.78. Then the average result of the media expert's kappa moment on the E-Module is 0.79 with the "High" category.

Practicality by Teachers

E-Modules that have been declared valid by material experts and media experts, then test the practicality of E-Modules to practitioner experts, namely chemistry teachers at SMAS Kartika I-2 Medan consisting of 2 teachers teaching chemistry subjects at the school. The

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following graph of the kappa moment results of practicality by teachers can be seen in Figure 3

Figure 4 Graph of kappa moment of practicality by teachers on E-Modules

In the graph, it can be seen the results of the kappa moment of each teacher's assessment on each aspect. The results of the kappa moment of practicality by teachers in each aspect, namely: aspects of design and content of 0.98, in the aspect of benefits of 1, and in the aspect of learning time efficiency of 1. Then the average result of the kappa moment of practicality by teachers on the E-Module is 0.99 with the category "Very High".

Learner Response

The students' response questionnaire was given after the developed E-Module was declared valid and practical. The students' response questionnaire was distributed to 33 students of class XI IPA 2, containing 6 aspects with 31 questions. The following is the average result of the kappa moment of the students' response which can be seen in table 3.

Table 3 Average results of kappa moment of learner response

Number	Aspect	Average (k)
1.	E-Modules	0,83
2.	Clarity of writing on the E-Module	0,8
3.	Clarity of images on the E-Module	0,83
4.	E-Module cover	0,8
5.	Color composition on the E-Module	0,84
6.	Benefits	0,78
Average 0.81 (Very High)		

Based on Table 2, the average kappa moment results of learner responses given to students of class XI IPA 2 SMAS Kartika I-2 Medan. So that the average value of the overall kappa moment of the students' response is 0.81 with a "very high" category. So the STEM-PjBL Based E-Module on acid-base material gets a good response from students.

Effectiveness Testing

This study aims to determine the improvement in learning outcomes before and after using the STEM-PjBL Based E-Module by calculating N-Gain based on pretest and posttest questions in class XI IPA 2. The increase can be calculated using the N-Gain formula as follows:

$$\text{N-Gain} = \frac{posttest\ score - pretest\ score}{ideal\ maximum\ score - pretest\ score}$$

High and low scores are determined based on the criteria in this table

Table 4 Classification of N-Gain Values

N-Gain Value	Criteria
N-Gain ≥ 0,70	High
0,30 < N-Gain < 0,70	Medium
N-gain ≤ 0,30	Low

(Karinaningsih, 2010)

Previously, the questions used were valid questions from Salsabila Hirza's research (2019). The calculation of the effectiveness test for each learner can be seen in the attachment. The results of the effectiveness test calculation can be seen in table 3 below:

Table 5 Average N-gain score of class XI IPA 2

Pretest Average	Posttest Average	N-Gain	Category
22,42	66,3	0,52	Medium

Based on Table 4.12, the results of the N-gain test show that there are changes that occur before and after applying the STEM-PjBL Based E-Module on acid-base material, a value of 0.52 is obtained in the "Medium" category.

4. Dessiminate

This stage is carried out by researchers on a limited basis by distributing the final product in the form of a STEM-PjBL-based E-Module on acid-base material in the form of a link and accessed in a flipbook display. Online distribution is done to make it easier for students to access E-Modules. The access that can be used by visiting the flipbook link listed below using an android or PC.

Link *flipbook* : https://online.fliphtml5.com/kkkpl/fmdm/index.html

Conclusion

The conclusion that can be obtained from the STEM-PjBL-based E-Module development research on acid-base material is: The conclusion that can be obtained from the STEM-PjBL-based E-Module development research on acid-base material is: The results of the needs analysis obtained from the teacher are that the teacher uses the lecture method and has not maximally used the PjBL learning model, the learning media used is only *Powerpoint* and has never used E-Modules and does not know the term STEM in learning. The validity level of the STEM-PjBL-based E-Module on acid-base material was declared valid with an average kappa moment of 0.82 with a "very high" category. The level of practicality by teachers was declared practical with an average kappa moment assessment of 0.99 in the "Very high" category. The effectiveness of the STEM-PjBL-based E-Module on acid-base material was declared effective by obtaining an average N-gain value of 0.52 in the "Medium" category. The response of students in class XI IPA 2 obtained an average value of 0.81 with the category "very high".

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Recommendation

Suggestions for future researchers, STEM-PjBL-based E-Modules on acid-base material can be further developed in experimental research methods so that they can be tested on large groups. This E-Module only discusses acid-base material, it is hoped that in the future it can develop STEM-PjBL-based E-Modules on other chemical materials. The disadvantage of this STEM-PjBL-based E-Module is that the color used as the basic background on the E-Modu is less attractive, because the color used is white. The obstacles experienced during the research process are in viewing the E-Module that does not look big because the infocus used is too close so that the STEM-PjBL-Based E-Module looks small.

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