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Research Article

Development of modules macromolecules based on local natural resources of Maluku in project-based learning for XII grade senior high school students

Vivian Salelatu, Eli Rohaeti

Chemistry Education Study Program, Faculty of Mathematics and Natural Science, Yogyakarta State University, Yogyakarta 55281, Indonesia

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Keywords

Local natural resources
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4D model

Corresponding author:
E-mail:
viviansalelatu.2021@student.uny.ac.id
(Vivian Salelatu)

Abstract

This research aims to develop chemistry learning modules based on local natural resources in Maluku in project-based learning on macromolecular material class XII IPA SMA. This research refers to the 4-D development model by Thiagarajan, Semmel, and Semmel, which includes the stages of define, design, develop, and disseminate. This learning module has gone through the validation stage by expert validators. It has gone through field trials and has been revised by developers to produce a valid and practical learning module. The results of this study are: (1) validity assessment by one media expert and one material expert is in the very valid category with an average score from material experts of 4.49 and an average score from media experts of 4.68; (2) the small group trial to 9 students of class XII IPA 1 SMAN 6 Ambon obtained a percentage of 93.6% in the very practical category; (3) Field trials to 30 students of class XII IPA 3 SMAN 12 Ambon resulted in a percentage of 90.2% with a very practical category. The response of five chemistry teachers to the developed module also resulted in a percentage of 85.4% in the very practical category. In conclusion, the chemistry learning module based on local natural resources in Maluku in project-based learning developed with a 4-D model is valid, practical, and It can be used as teaching materials in school.

Introduction

Maluku Province, including the eastern part of Indonesia, has the potential for abundant natural wealth in the food and marine sectors (Leatemia and Wattimena, 2021). However, the diversity of ecosystems in Maluku has yet to be widely developed into teaching materials for chemistry learning in schools (Masihu and Agustyn, 2021). According to Ramly et al. (2022), chemistry learning that pays attention to local natural products is one of the things that need to be considered in curriculum development in Indonesia, especially in the chemistry curriculum at the secondary school level (Imansari and Sumarni, 2018). According to the findings of the questionnaire provided to the chemistry teacher, the teaching materials that were often used only contained a summary of the subject matter and some practice questions. The teaching materials used have not been widely associated with daily life, so students are less encouraged to produce chemical products from local natural products. Teachers rarely create learning modules that integrate local natural resources into chemistry learning in the classroom. The lack of teaching materials makes students less enthusiastic about participating in the learning process because textbooks only encourage students (Maharani et al. 2022). The characteristics of participants with a visual learning style should be supported by modules or teaching materials suitable for students. Using the module, students can repeat learning the material at home (Syahrizal, 2019).

On the other hand, macromolecular material by most students is considered boring because it is only limited to learning the theory (Lestari and Guspanti, 2023). When referring to the high school chemistry curriculum for macromolecular materials, one indicator requires students to make projects an impact on

macromolecular learning. However, these indicators are only sometimes implemented by teachers during chemistry lessons. These indicators can allow students to produce a project through chemistry teaching in class.

The development of chemistry modules integrated with innovative learning models has been widely carried out at all levels of academic units (Sutiani and Maisyarah, 2021). One innovative learning model is the Project Based Learning learning model (Munthe et al. 2019; Indrayati et al. 2021). From the results of a questionnaire distributed to high school teachers in Maluku to analyze the initial needs in the preparation of modules, it was found that the project-based learning model still needed to be widely applied when chemistry learning took place in the classroom. In fact, According to Qholby (2020) the students can demonstrate concretely that they have learned essential ideas and skills through projects that require them to: (1) solve real problems and issues that are important to others; (2) actively engage in their learning and choose necessary items during the project; and (3) show concrete evidence of having learned essential concepts and abilities (Guo et al. 2020).

Many relevant studies have been carried out. According to research by Hasibuan et al. (2020), creating project-based learning modules can affect students' motivation and learning competency. According to another studies cited by Haatanien and Aksela (2021), project-based learning helps teachers and students in schools understand topics and enhance their skills. Salazar et al. (2023) study discovered that project-based learning can increase students' capacity for original thought. As a consequence of their investigation, Mahanan et al. (2021) came to the conclusion that project-based learning may benefit from the creation of two module models. The issue has been explained above, inspiring the author to research module development. This study aims to develop learning modules for project-based learning on macromolecular materials using Maluku's native natural resources that are valid and practical for use in chemistry lessons.

Method

R&D (Research and Development) is the research methodology used. The stages of define, design, develop, and disseminate are all included in this research model's 4-D process (Kasih et al. 2021). The study's participants included class XII students at one of the senior high schools in Ambon, five chemistry teachers, and two instrument validators, including media experts and material experts. Validation analyses and questionnaires about the applicability of modules were used in this study to collect data. The instruments used in this study were materials validation sheets, media validation sheets, student response questionnaire sheets, and teacher response questionnaire sheets. The module validity assessment instrument item is prepared based on the guidelines of the National Education Standards Agency (BNSP), covering graphic validity, language validity, content validity, and presentation validity. In contrast, the teacher response instrument grid includes module, material, language, and presentation aspects.

Table 1. Product Category Validity

Interval Score	Category
$4.10 < \overline{X} \leq 5.00$	Very Valid
$3.10 < \overline{X} \leq 4.10$	Valid
$2.10 < \overline{X} \leq 3.10$	Valid Enough
$\overline{X} < 2.10$	Invalid

Table 2. Practicality Value Criteria

Percentage (%)	Criteria
0-20%	Impractical
21-40%	Less Practical
41-60%	Quite Practical
61-80%	Practical

Validity Analysis

Expert validation data is examined by considering validator inputs, comments, and suggestions. The analysis's findings serve as a guide for updating the created modules. The validation sheet's measuring scale employs a 5

(five). A formula is used to calculate the validation results' average score, which is calculated by dividing the total score by the number of aspects evaluated (Sujana, 2016):

$$\bar{X} = \frac{\sum Xi}{n}$$

$\bar{X}$ = Average validation score
$\sum X_i$ = The overall validation result score
n = The number of aspects evaluated

In addition, Arsyad (2016) provides an interpretation of the average score in the validation category, which can be found in Table 1.

Teacher and Student Analysis of the Response

Based on the findings of surveys that teachers and students had completed, responses to the generated instructional materials were examined. A rating score measurement scale with a maximum value of 5 (five) was employed in this study. The following formula is then used to process the questionnaire's data:

$$\text{Practicality Value} = \frac{Total\ obtained\ score}{Maximum\ score} \times 100\%$$

The acquisition results are transformed to the following Table 2 once the proportion of the product's usefulness is determined.

Results and Discussion

Chemistry modules based on local Maluku natural resources have been designed for project-based learning with grade XII students using a 4D development paradigm with phases for define, design, develop, and disseminate. The created chemistry module is designed in A4 format (21 x 29.7 cm) (Fig.-1 and Fig.-2).

The define stage is carried out by needs analysis and learning tool analysis. Needs analysis includes curriculum analysis, syllabus, and lesson plans. Based on the analysis results, the curriculum used is the 2013 curriculum. In contrast, the description of macromolecular matter is shown in Table 3.

Table 3. Macromolecular Material

Basic Competencies	Subject Matter
3.11 Analyze the structure, nomenclature, properties and classification of macromolecules 4.11 Analyze the results of searching for information about the manufacture and impact of a product from macromolecules	Structure, nomenclature, properties, use and classification of macromolecules •Polymer •Carbohydrates •Protein •Lipid

Analysis of learning tools includes learning resources used in the learning process. Learning resources used in the learning process are textbooks and student worksheets. In the student's books and worksheets, there are no project assignments. Project tasks train learners always be active and imaginative in integrating ideas and skills with real life to produce chemical products. In addition, in this initial analysis, a questionnaire was carried out for the preparation of modules by teachers to find out fundamental problems and conclude learning needs following the scope of chemistry learning by considering local natural resources.

The design stage is carried out by compiling a draft macromolecular module development design consisting of a module cover, module usage guide, foreword, table of contents, concept map, basic competencies (KD), core competencies (KI), learning objectives, introduction, material description, sample questions, discussion of questions, scoring guidelines, practice questions, summaries, practicum activities for making projects, evaluation, and answer keys.

The development phase is a feasibility assessment of project-based macromolecular modules using assessment instruments from the National Education Standards Agency (BSNP) assessed by expert validators. Two experts assess consist of one learning media expert and one material expert lecturer from FMIPA lecturers

Yogyakarta State University. The dissemination stage is done by disseminating modules to students and subject teachers through the Chemistry MGMP community in schools.

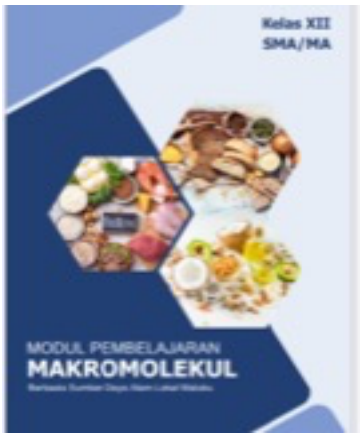

Fig.-1. Module Cover Display

Fig.-2. Partial Display of Module Contents

Content Validation Results

Validation by content experts focuses on the module's content that is evaluated by specialists in the field of chemistry. The following (Table 4) lists the findings of the review of the macromolecular material composition in the chemistry module.

Table 4. Results of material expert validation

Assessment aspect	Average Score	Category
Content Feasibility line with BSNP	4.33	Very Valid
Linguistic Feasibility line with BSNP	4.75	Very Valid
Presentation Feasibility line with BSNP	4.66	Very Valid
Graphics Feasibility line with BSNP	4.25	Very Valid
Average	4.49	Very Valid

Table 4 reveals that subject-matter experts' evaluation findings (validation) had an average total score of 4.49 or were classified as highly valid criteria. Content received an average score of 4.33 for eligibility; 4.75 for linguistics; 4.25 for presentation feasibility; 4.25 for graphics; and 4.50 for overall impression. Based on the evaluation results by material expert validators, the project-based learning on macromolecular materials in the chemistry module of class XII pupils based on local natural resources in Maluku was determined to be highly valid. The suggestion for module improvement from content experts is to add practice questions.

Learning Media Expert Validation Results

Learning design experts test the product's feasibility in delivering learning through modules. The findings of validation by professionals in learning design are shown in Table 5.

Table 5. Media expert validation results

Assessment aspect	Average Score	Category
Content Feasibility line with BSNP	4.83	Very Valid
Linguistic Feasibility line with BSNP	4.66	Very Valid
Presentation Feasibility line with BSNP	4.75	Very Valid
Graphics Feasibility line with BSNP	4.50	Very Valid
Average	4.68	Very Valid

According to Table 5, the evaluation findings conducted by media experts (validation) received an overall average score of 4.68, which indicates that these criteria are considered highly valid. The recommendation made by media professionals for enhancing the module is to pay attention to the neatness of the paragraphs. Therefore, based on the research conducted by the two expert validators, it was determined that the chemistry module for macromolecular materials based on local natural resources in Maluku in project-based learning of

students in grade XII is feasible for development trials on target users, specifically students and teachers. This conclusion was reached due to the research findings conducted by the two expert validators.

Teacher Assessment Results

After getting an assessment from material and media experts, researchers make revisions based on the advice provided by validators. Furthermore, a development trial was conducted on chemistry teachers to analyze teacher responses to chemistry modules based on local natural resources in Maluku in project-based learning of grade XII students on the macromolecular material developed. The number of teachers who were the subjects of the study was five chemistry teachers consisting of one teacher from YPKPM Ambon Christian Senior High School (Teacher 1), one teacher from SMAN 12 Ambon (Teacher 2); one teacher from Pertiwi Ambon Senior High School (Teacher 3); one teacher from SMAN 4 Amahai (Teacher 4); one Teacher from SMAN 1 Seram Barat (Teacher 5).

Tabel 6. Teacher response questionnaire results

Re-spondents	Module	Assessment aspect			Total Score	Maximum Score	Percentage
		Content	Linguistic	Presentation			
Teacher 1	9	28	25	17	79	90	88%
Teacher 2	7	25	28	17	77	90	83%
Teacher 3	8	27	25	18	78	90	87%
Teacher 4	8	24	28	16	76	90	84%
Teacher 5	8	25	28	16	77	90	85%
Average							85.4 %

Table 6 shows that the outcomes of development trials conducted on five class XII chemistry teachers were incredibly realistic achievement qualifications with a percentage of 85.4%. According to the teacher's evaluation results, the chemistry module for students in grade XII that focuses on macromolecular material and uses local natural resources in Maluku generates a very practical average. Suggestions from teachers include adding local natural products from Maluku that are relevant to macromolecular materials such as the addition of images of processed cakes or snacks from sago, fish shredded products that are famous in Maluku, and types of food products that contain fat, such as margarine and clove oil. The importance of adding images of processed Moluccan products into the module to connect learning with students' daily lives. In line with this, research by Rusmansyah et al. (2023) shows that linking learning with daily life can improve student learning outcomes. On the other hand, the presence of pictures can make students feel enthusiastic and not bored because the material is dominated by theory. Research conducted by Mahmudah et al. (2022) revealed that adding images relevant to the material into the module can make the module interesting so that students can be motivated to follow learning.

Small Group Trial Results

After the teacher gives an assessment, the researcher revised according to the advice given by the teacher. The next step is to conduct a small group test for nine students at SMA Negeri 6 Ambon. Module assessment indicators include aspects of module functions and benefits for students, material aspects, module presentation, and language aspects. Small respondents examined the assessment of development products through hard copy and soft copy modules. The following are the findings from the small group trial data analysis (Table 7).

Table 7. Small Group Trial Result

Respondents	1	2	3	4	5	6	7	8	9
Total Score	112	113	113	114	108	114	114	115	110
Percentage (%)	93.3	94.1	94.1	95	90	95	95	96	91.6
Maximum Score	120								
Average	93.6 %								

The development results from the module's small group testing analysis revealed an average percentage of 93.6%, falling under the very practical category.

Field Trial Results

In the field test stage, the module was piloted involving 30 students from class XII at SMA Negeri 12 Ambon. The data from field trials are shown in the following (Table 8).

Table 8. Student Field Test Results

Respondents	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Score	109	108	113	106	105	113	103	110	115	116	107	114	115	113	112
Percenatge (%)	90.8	90	94.1	88.3	87.5	94.1	94.1	91.6	95.8	96.6	89.1	95	95.8	94.1	93.3
Max Score	120														

Respondents	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Score	114	115	113	115	107	111	113	106	115	114	116	109	107	112	110
Percentage (%)	95	95.8	94.1	95.8	89.1	92.5	94.1	88.3	95.8	95	96.6	95	95.8	94.1	93.3
Max Score	120														
Average	90.2%														

Table 8 demonstrates that the average percentage of student assessment questionnaires for modules in field trials is 90.2%, indicating that modules are highly practical qualifications. The results of the development module can be applied to chemistry education in schools. According to research, module writing aims to facilitate and clarify the presentation of communications so that they are not overly verbose (Nurul, 2023). Modules can also help students and teachers surmount limitations of time, space, and sensory capacity (Manaf, 2022). The use of modules can aid in the education of students (Wahdini, 2023). Using modules also improves student learning motivation (Indriana et al. 2023). Self-instruction in modules that can guide student learning even with a limited instructor role is also helpful (Puspita Sari et al. 2023). The research findings of Sihombing et al. (2022) indicate that developing Project-based learning modules can enhance student learning outcomes. In accordance with this, Ching and Hsin (2023) explained in their research findings that the development of project-based learning modules could be used to train children's scientific skills in schools. Additionally, research by Nastiti et al. (2018) demonstrates that module development can enhance students' generic science abilities and learning outcomes. The development of teaching materials, such as modules in the learning process, must be done to create effective and efficient learning. Thus, modules can encourage student independence in learning (Spencer and Rouker, 2023).

Conclusion

The development of modules based on local natural resources in Maluku for project-based learning for class XII science macromolecular material was successful and applicable based on the findings of expert validation and practicality tests. The validation of material experts reached an average score of 4.49 and met the criteria for the very valid category. The validation of media experts reached an average score of 4.68 and met the criteria for the very valid category. Therefore, the developed chemistry module products are suitable for educational use. The practicality test of the module by five chemistry teachers obtained a very practical qualification with a percentage of 85.4%. Small group tests have a percentage of 93.6% with a very practical category, and field trials have a 90.2% with a very practical category. From the responses or responses given, the chemistry module developed can be used as a learning resource for grade XII students and as teaching material for teachers in schools.

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

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