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DEVELOPMENT OF A SCIENCE (CHEMISTRY) PROJECT TEACHING MODULE IN THE MERDEKA CURRICULUM AS A TEACHER'S GUIDE FOR LEARNING IN CLASS X VOCATIONAL SCHOOLS

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ABSTRACT

This research is a development research that aims to produce an IPAS (Chemistry) Project teaching module as a teacher's guide in learning, which is feasible in terms of validity and practicality. This module development adapts the 4D model (Define, Design, Develop, Disseminate) because the stages are arranged in detail and systematically, involving revisions, trials, and validation by experts. The test subjects were class X students of SMKN 1 Narmada with the Agribusiness of Agricultural Product Processing (APHP) expertise program. The research instruments included validation sheets and student and teacher response questionnaires. Data analysis used descriptive statistics, with module validity calculated using Aiken's V formula, and module practicality analyzed using a Likert scale. The results showed the average validity of the four validators was 0.861, which was classified as very valid. The level of understanding between validators was tested using the Percentage of Agreement (R) method, resulting in an average of 0.90 with a reliable category. The practicality of the module based on teacher and learner response questionnaires showed an average percentage of 94% and 81%, respectively. Based on these results, it can be concluded that the IPAS (Chemistry) Project teaching module on substance material and its changes for class X SMK has a high level of validity and practicality, so it is suitable for use in the learning process.

ABSTRAK

Penelitian ini bertujuan untuk menghasilkan modul ajar Projek IPAS (Kimia) sebagai panduan guru dalam pembelajaran, yang layak ditinjau dari segi kevalidan dan kepraktisan. Pengembangan modul ini mengadaptasi model 4D (*Define, Design, Develop, Disseminate*) karena tahapannya disusun secara detail dan sistematis, melibatkan revisi, uji coba, serta validasi oleh para ahli. Subjek uji coba adalah siswa kelas X SMKN 1 Narmada program keahlian Agribisnis Pengolahan Hasil Pertanian (APHP). Instrumen penelitian meliputi lembar validasi serta angket respon peserta didik dan guru. Analisis data menggunakan statistik deskriptif, dengan kevalidan modul dihitung menggunakan rumus Aiken's V, dan kepraktisan modul dianalisis menggunakan skala Likert. Hasil penelitian menunjukkan rata-rata kevalidan dari empat validator adalah 0,861, yang tergolong sangat valid. Tingkat kesepahaman antar validator diuji dengan metode Percentage of Agreement (R), menghasilkan rata-rata 0,90 dengan kategori reliabel. Kepraktisan modul berdasarkan angket respon guru dan peserta didik menunjukkan persentase rata-rata masing-masing sebesar 94% dan 81%. Berdasarkan hasil tersebut, dapat disimpulkan bahwa modul ajar Projek IPAS (Kimia) pada materi zat dan perubahannya untuk kelas X SMK memiliki tingkat validitas dan kepraktisan yang tinggi, sehingga layak digunakan dalam proses pembelajaran.

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INTRODUCTION

The Vocational High School curriculum in Indonesia has a strategic role in creating competent graduates who are ready to compete in the world of work. To support this goal, the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) has implemented the Independent Curriculum in SMK. This curriculum requires attention to various aspects, such as teachers' understanding of learning outcomes, the ability to compile teaching materials, and the application of appropriate learning methods (Astina et al., 2023). One of the new subjects in the Independent Curriculum in Vocational high school is the Natural and Social Sciences Project (IPAS Project), which is a combination of chemistry, physics, biology, and social subjects (Linda, 2023). In the IPAS Project, one aspect of chemistry studied is substances and their changes, which discusses elements, compounds, and mixtures in the context of the creative and social economy (Kemendikbudristek, 2023). This curriculum integrates project-based learning (PjBL) to provide practical and collaborative experiences, so that students can develop their soft and hard skills (Muhammadiah et al., 2023).

The Independent Curriculum teaching module is designed as the main learning tool that replaces traditional lesson plans. This module includes learning materials, evaluation methods, and activities that are structured according to the Learning Objectives Flow and Learning Outcomes with a focus on developing the Pancasila Student Profile (Sesmiarni & Asi, 2023; Maarif, 2022). With this approach, teachers can apply contextual and flexible learning to meet students' needs (Purnawanto, 2022). The teaching module also functions as a strategic guide in project-based learning, which emphasizes the development of critical thinking skills and student independence (Dwiantoro & Basuki, 2021; Ramdhayani et al., 2023).

However, specific teaching modules for chemistry material, especially substances and their changes, are still limited at SMKN 1 Narmada. Initial observations show that the available modules are still general and not project-based. In fact, the project-based approach has been proven effective in improving students' conceptual understanding and metacognitive skills (Nurhamida & Andromeda, 2023). Therefore, it is necessary to develop PjBL-based teaching modules that are relevant to the needs of vocational high school students, especially in the Agribusiness Agricultural Product Processing expertise program.

The novelty of this study lies in the development of PjBL-based teaching modules for the material of substances and their changes in the Science Project subject at the vocational high school level, which is different from previous studies, such as those conducted by Nurhamida & Andromeda (2023) at the high school/vocational high school level. This teaching module is expected to be a practical guide for teachers in learning, while providing real benefits for students by integrating aspects of chemistry in the context of the creative and social economy.

Based on this background, this study aims to develop a teaching module for the Science Project (Chemistry) based on PjBL in the Independent Curriculum as a guide for teachers in grade X of vocational high school. This module is expected to make it easier for teachers to carry out chemistry learning, especially on

the topic of substances and their changes, as well as provide relevant and contextual learning experiences for students.

METHOD

The development of the module in this study adapted the 4D development model (Define, Design, Develop, Disseminate) because this approach has systematic and structured advantages to produce valid, practical, and effective learning products. The product developed in this study is a teaching module for the Science Project (chemistry) as a guide for teachers in learning about substances and their changes in class X of SMK. The test subjects in this study were class X students of the Agribusiness and Agricultural Product Processing (APHP) expertise program at SMKN 1 Narmada.

The research instrument is a tool used by researchers to collect data, measure phenomena, and analyze data that is in accordance with the problems faced by the subjects or samples observed. Instruments have an important position in research because they greatly influence research conclusions (Kurniawan, 2021). The instruments used in this study were expert validation sheets to measure the validity of the teaching module and teacher and student response questionnaires to obtain answers to research questions, with the aim that the information obtained can solve predetermined research problems. Opinions and comments are used to revise the developed module.

The data analysis technique in this study uses descriptive statistical analysis. Descriptive statistics is one of the statistical methods related to collection and presentation so that it can provide useful information (Martias, 2021). Data analysis in this study, namely: expert validation data analysis, instrument reliability, and practicality analysis of teaching modules. Expert validation data analysis is calculated using the Aiken's V formula (Astuti et al., 2024) which is formulated in formula (1) and (2) as follows:

$$V = \frac{\sum S}{[n(c-1)]} \quad \ldots 1)$$

$$S = r - I \quad \ldots 2)$$

Description:

V: Validation agreement index

S: Score set by the validator minus the lowest score in the category used (s = r-I, where r = score of the validator's chosen category and I = lowest scoring score).

N: Number of validators

c: Number of assessment categories assessed by the validators

The analysis used to determine the level of reliability by two validators (on the same two aspects) uses the Borich equation in formula (3) as follows:

$$\text{Percentage of Agreement (R)} = 100(1 - (A-B/A+B)) \text{ x } 100\% \quad \ldots(3)$$

Description:

A = the assessment result of the validator who gave a higher value

B = the assessment result of the validator who gave a lower value

The instrument is said to be reliable if the reliability coefficient is ≥ 75% (Imawati et al., 2022)

The analysis of the practicality questionnaire is calculated using the formula (4) as follow:

$$p = f/\text{n } x \text{ } 100\% \quad \ldots(4)$$

Description:
p = percentage of practicality
f = number of scores per assessment aspect
N = Maximum score
(Qomaria & Tsulutsya, 2024)

4D Model Research Design (Define, Design, Develop, Disseminate)

Definition Stage (Define)

The definition stage is the stage to determine the product that will be made as a medium in making the learning process effective. This stage is to determine and define learning needs. Determination of needs is done by considering and adjusting the appropriate chemistry learning needs for vocational schools and material aspects.

There are five activities that developers can do at this definition stage, namely: [1] Front-end analysis (beginning-end analysis): identifying and determining the basis of problems that arise during the learning process and becoming the basis for development needs. At this stage, researchers look for the main problems in learning activities through observation. [2] Learner analysis (student analysis): researchers identify the characteristics of students targeted to develop learning modules. [3] Task analysis (task/material analysis): starting by analyzing aspects of the Science Project (chemistry) and learning achievements according to the independent curriculum to formulate learning objectives and indicators, and determine the material or content of activities in the module being developed. [4] Concept analysis: this stage is an important step in building the concept of the material used as a means of achieving basic competencies. Concept analysis is carried out to examine aspects of science and natural sciences, elements and learning outcomes in accordance with the independent curriculum. [5] Specifying instructional objectives: this stage is the formulation of learning objectives, which involves determining specific and measurable learning objectives that are in accordance with the independent curriculum and applicable competency standards.

Design Stage

The design stage aims to produce a design for the Science and Natural Science (Chemistry) Project teaching module product based on the define stage. The main aspects in the design stage are the selection of media and formats for teaching materials and the creation of an initial version. This stage consists of four steps, namely: first, the preparation of test standards used to measure students' understanding and achievement of the learning objectives that have been set. Second, the selection of media in the development of teaching modules that are in accordance with the learning objectives to be achieved, student characteristics, learning context, availability and accessibility of media, and the effectiveness of the media itself. Third, the selection of a teaching module format that is in accordance with the curriculum, namely starting from general information, core components including: learning objectives, meaningful understanding, trigger questions, learning activities, assessments, and reflections, and there is an appendix section. Fourth, making an initial design in the form of making a module cover and the contents and arrangement of teaching module materials. The initial design in this module is to make a sketch (storyboard) with the aim of visually planning the flow of the teaching module before being developed as a whole.

Development stage

The development stage is the stage of compiling a teaching module that was previously compiled at the initial design stage. The existence of this develop stage is the stage for compiling teaching modules and making improvements. This process consists of three stages, namely, the first stage is the development stage which aims to develop the product in this study in the form of a teaching module for the Science Project (Chemistry) as a teacher's guide to the material on substances and their changes in grade X SMK according to the established format. The second stage is the validation stage, which is the stage of expert assessment used to obtain recommendations for improving the teaching module that has been made. At this validity test stage, the researcher asked the validator to validate the learning module that had been developed in the form of prototype learning module 1. The results of the validation carried out by the validator were then used as a guideline or instruction to make improvements to the teaching module and obtained prototype teaching module 2. The third stage is the trial stage, this stage is a practicality trial designed to evaluate the extent to which the module can be applied and provide the desired learning outcomes. The first stage in the trial procedure is to determine the sample group, namely students who will be trial participants. After that, the teaching module is introduced to the sample group in a structured learning session. Furthermore, the practicality test is obtained through a questionnaire of teacher and student responses to the implementation of the module that has been carried out. The results of the trial are analyzed to determine the practicality of the Science Project (Chemistry) teaching module.

Dissemination Stage

The developed teaching module is promoted through the dissemination stage so that it can be accepted by individuals, groups, or systems. In the dissemination stage in this study, the dissemination was carried out at the research location, namely SMKN 1 Narmada, in print and through digital publications.

RESULT AND DISCUSSION

Define Stage

This stage consists of Front-end Analysis, Learner Analysis, Task Analysis, Concept Analysis, and Specifying Instructional Objectives. In this stage, the researcher defines or finds out what is needed, concepts, evaluations, and learning specifications that will be applied later in the module by analyzing. Based on the results of the initial analysis, the problem found was the unavailability of a project-based Science Project (Chemistry) teaching module on the material of substances and their changes at SMKN 1 Narmada.

This analysis stage was carried out by interviewing chemistry teachers at the target school of the study, who stated that the teaching materials used were not project-based, especially in the aspect of chemical material, namely substances and their changes, and the Science Project textbook was also not available at the school. The Project-Based Learning (PjBL) approach is suitable for this material because it provides students with the opportunity to learn through direct experience. PjBL has proven to be more effective in helping students understand chemical concepts while improving their critical thinking skills. The materials used in the module are substances and their changes which discuss the types of changes in substances and examples, the main groupings in the classification of matter, the characteristics of changes in

substances, and substances and changes in the food processing process which include: physical changes in substances that occur, the main role of materials in the manufacturing process, and types of tests carried out in the processing process, especially in the production of jam. Through this subject, students who are the subjects of the research, namely students with the Agricultural Product Processing Agribusiness expertise program, are expected to be able to develop agricultural products to be more durable, increase production capacity, and increase the selling value of products so that understanding chemistry is very important in supporting the mastery of competencies in the agricultural product processing department at vocational high school. The activities carried out in the task analysis are to identify and compile the materials to be studied systematically. There are two learning activity activities that will be compiled where each meeting students work on student worksheets. For learning activities at the first meeting, students are given a basic understanding of the material, design product planning, and work on student worksheets. In the first meeting student worksheets, several activities that students will do are: identifying types of substances in the environment based on physical and chemical characteristics; explaining the meaning of changes in the state of matter and providing examples of changes in the state of matter; watch a video of the jam making process to answer questions, then group examples of substances in everyday life that include elements, compounds, and mixtures and analyze the differences in types of changes in an event.

The second meeting learning activity, students carry out a project, namely an organic product processing project (pineapple jam). In the second meeting student worksheets, the activities carried out by students are: writing down the results of project observations, answering questions regarding the analysis of observation results, analyzing the manufacturing process, and compiling a final report.

Concept analysis is carried out by reviewing Learning Outcomes and Learning Objective Flow according to the curriculum used as the basis for formulating learning objectives. Based on the analysis of the learning objective flow carried out starting from explaining the concept of material, identifying types of substances, classifying substances, then carrying out scientific investigations on making jam. Therefore, the overall learning objectives after analyzing Learning Outcomes and Learning Objective Flow are: describing the types and properties of substances that are distinguished chemically and physically; identifying the characteristics of changes in substances physically, chemically, and biologically; explaining the concepts of elements, compounds, and mixtures in the context of everyday life; making processed products by conducting scientific investigations on making jam as an effort to develop the creative and social economy, and linking the skills possessed according to the Agricultural Product Processing Agribusiness expertise program with substances and their changes.

This concept analysis is arranged into a learning flow. Clear learning mapping can help students organize the information needed in the learning process so that students do not experience misconceptions in receiving learning materials (Darnella et al., 2020).

Design Stage

The design stage aims to create an initial design of the module components consisting of four steps, namely: [1]

Preparation of Test Standards where the types of tests used in this teaching module are diagnostic assessments and summative assessments. The diagnostic assessment is in the form of a multiple-choice pretest while the summative assessment is in the form of student project reports and presentation of project presentation results. [2] Selection of media in the form of product creation videos to support students in answering questions and working on projects on the student worksheets. [3] Selection of a teaching module format that is in accordance with the curriculum used, namely the independent curriculum. The independent curriculum teaching module has a writing system based on the Learning and Assessment Guidelines. In general, teaching modules have 3 components, namely general information, core components, and attachments (Kartikawati et al., 2022). [4] Making an initial design in the form of a sketch to visualize the flow of the teaching module before being developed as a whole.

Development Stage (Develop)

The development stage (develop) aims to develop a product which in this study is a project-based Science Project (Chemistry) teaching module on the material of substances and their changes in grade X vocational high school. The development of this teaching module begins with the stages of student analysis, task analysis, concept analysis and formulation of learning objectives. Then continued with the design stage which includes the preparation of test standards, media selection, format selection, and making an initial module design. After the teaching module is designed, the next step is to create a teaching module that will be assessed by the validators. The teaching module that has been produced through several stages of revision from the validator will become prototype II. Furthermore, its practicality is tested in the class that is the subject of the research.

Table 1. Expert validation test results

Assesment aspect	Validator score						Description
	V1	V2	V3	V4	Σs	mean	
	4.7	4.7	4.4	4.0	13.8	0.86	Very valid
Eligibility of content	4.3	4.6	4.3	4.0	13.1	0.82	Very valid
Clarity of the contents of the module components	5.0	5.0	5.0	4.2	15.2	0.95	Very valid
Learning Activities	4.4	4.7	4.7	4.3	14.0	0.87	Very valid
Suitability of learning models	4.6	4.8	4.6	3.9	14.0	0.87	Very valid
Evaluation	4.1	4.6	4.2	3.6	12.6	0.78	Valid
mean score						**0.86**	**Very valid**

The average value of the 6 assessment aspects is 0.86. Based on this value, the teaching module of the Science Project (Chemistry) as a teacher's guide for learning developed by researchers is in the valid category so that it is suitable for teachers to use in learning. The reliability test was carried out using the Percentage of Agreement (R) equation. The determination of the R value was carried out for each component and the results were obtained as in Table 2:

Table 2. Reliability test results

No	Aspects	R
1.	Aspects of content suitability	0,91
2.	Aspects of clarity of module component content	0,94
3.	Aspects of learning activities	0,89
4.	Aspects of suitability of learning models	0,94
5.	Aspects of assessment	0,89
6.	Aspects of language	0,88
mean		0,90

Based on the overall average aspect for validator understanding of 0.90. So it can be concluded that the validation instrument developed has been reliable or can be trusted because it has a value (R) ≥ 0.75 or ≥ 75%.

The practicality test is a trial that aims for researchers to conduct limited trials of the chemistry learning module that has been developed. This test data was obtained from teacher response questionnaires and student response questionnaires.

Table 3. Results of teacher practicality test

No	Aspect	% Practicality	Criteria
1.	Learning	95%	Very practical
2.	Quality of teaching modules	86%	Very practical
3.	Function of teaching modules	96%	Very practical
4.	Display of teaching modules	100%	Very practical
	mean	94%	Very practical

Table 4. Results of the students' practicality test

No	Aspect	% Practicality	Criteria
1.	Learning	81%	Very practical
2.	Ease of use of teaching modules	80%	Very practical
3.	Function of teaching modules	80%	Very practical
4.	Display of teaching modules	83%	Very practical
	Mean	81%	Very practical

The results of the practicality test of the developed chemistry learning module obtained an average value of 81% so that researchers can conclude that the developed learning module is categorized as very practical because the score obtained for this practicality test is in the range of 80% < x≤ 100%.

CONCLUSION

Based on the results of the research on the development of teaching modules that have been conducted, several conclusions were obtained that the teaching module of the Science Project (Chemistry) as a teacher's guide for learning in class X of SMK which has been developed using the 4D model (Define, Design, Develop, Disseminate) has very valid and practical criteria for use. The average validation value obtained for all aspects of the assessment is 0.861 which is in the very valid category. The level of reliability test (R) uses the percentage of agreement equation which obtains an average value from all aspects of the assessment, namely 0.90 with a reliable or trustworthy category. The level of practicality test of the Science Project (Chemistry) teaching module through teacher and student response questionnaires obtained average values of 94% and 81% respectively, which are included in the very practical category.

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