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Development of E-Module in Problem-Based Learning (PBL) on Biotechnology Material to Increase Learning Independence and Understanding of Concepts for Class XII SMA Students

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Abstract: The aim of this study are determine the feasibility of developing an e-module in problem-based learning (PBL) with the flipped classroom learning method on biotechnology material to increase students' learning independence and understanding of concepts; determine the practicality of developing e-modules in problem-based learning (PBL) using the flipped classroom learning method for biotechnology material to increase students' learning independence and understanding of concepts; determine the effectiveness of e-module development in problem-based learning (PBL) using the flipped classroom learning method for biotechnology material to increase students' learning independence and understanding of concepts. The results of this research indicate that the e-module in problem-based learning (PBL) with the flipped classroom learning method is stated: very suitable for use based on the assessment of material experts with a value of 3.8 conversion 95 with a very feasible category and the assessment of media experts with a value 4.00 100 conversions with very decent category; very practical to use based on the results of the Biology Teacher's assessment with a score of 4.00 conversion 100 in the very feasible category and student assessment with a score of 3.87 conversion 97 in the very practical category; is effectively used to increase learning independence and conceptual understanding of phase F students based on the MANOVA test $p < 0.05$. The development of an e-module in problem-based learning (PBL) using the flipped classroom learning method on biotechnology material is feasible, practical and effective to use.

Keywords: Electronic modules; Flipped classroom; Independent learning; Understanding concepts

Introduction

Education is very important for every student and for the progress of the country. There are three important benefits of education, such as improving the quality of knowledge, improving the quality of life and improving the quality of the economy (Abdullah & Rahman, 2012). First, education is able to improve the quality of students' knowledge and skills to face everyday life. Second, education can improve the quality of life, be able to understand yourself, and be able to find out your interests and talents. If students succeed in improving their quality of life, they will get better jobs, gain access to health services, and obtain other social services. Third, education can increase social and economic progress by creating a skilled and knowledgeable workforce, as well as increasing innovation and productivity. Education faces various challenges that affect the quality of good education (Agustina et al., 2018; Luis et al., 2019). The main challenge to education is educational equality, there are still many students who do not receive quality

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education. These challenges influence the low level of education in Indonesia. Several factors, including: geographical location of residence, parents' education level and parents' income level. The results of observations at SMAN 1 Cangkringan and SMAN 2 Wates show that not all education has the same quality, both in the learning and teaching process, especially in interactive learning media facilities that have not been improved and the use of technology has not been implemented. According to Riyanti (2021) and Hamzah et al. (2021), technology in education has the potential to improve the quality of education, but not all students can access technology and have the skills to use technology effectively.

21st century education is a century of knowledge characterized by the rapid development of technology and information. According to Agustinia et al. (2018), education in Indonesia has experienced many changes over time, one of which is changes to the curriculum in Indonesia that have occurred since 1947 until now. These changes aim to improve the quality of education in Indonesia and adapt to thought patterns and changing times. The results of the Program for International Student Assessment (PISA) survey (2022), show that education in Indonesia has a low quality education category, namely ranking 66th out of 81 countries. The Organization for Economic Co-operation and Development (OECD) survey (2016-2022), also shows that Indonesia's education is low and consistently ranks in the bottom 15.

The results of interviews with Biology Teachers at SMAN 1 Cangkringan revealed low learning independence and low understanding of students' concepts. The results of observations of students at SMAN 1 Cangkringan regarding low learning independence is one of the problems in the learning process which influences low learning outcomes. Several problems in the learning process in class, such as students being reluctant to do assignments before instructions from the teacher, playing games/sleeping during learning, and students not doing homework (PR). According to Aini et al. (2012), Hendrayana (2014), Yanuarto (2018), and Desi (2019), factors that influence learning independence are time management, learning organization, and effective learning strategies. If students have not developed these skills, they will find it difficult to learn independently.

Apart from the low level of learning independence, there is another problem, namely the low understanding of concepts at SMAN 1 Cangkringan class XII which also influences the low learning outcomes of students. This is due to several factors, such as the students' learning process not being optimal as seen from the results of the recapitulation of students' Biology scores which are still below the KKM, the results of the questionnaire, 70% of students said that it was difficult to learn modern biotechnology material, the lack of students taking part in science competitions, and facilities What teachers use in classroom learning activities only uses textbooks, worksheets and several modules which are still very limited.

Based on these problems, it is necessary to design learning media that can increase students' learning independence and understanding of conceptsis flexible so that students can learn anytime and anywhere. According to Setiadi (2017), e-module is an effective learning media for increasing students' learning independence and understanding of concepts. Based on a needs questionnaire, 80% of students at SMAN 1 Cangkringan agreed to use electronic media. According to Mulyadi et al. (2016), e-modules have an instant feedback feature that allows students to immediately understand the material and helps them prepare better in class. Developing an attractive and innovative e-module certainly requires designing a learning model that can help improve the quality of biology learning.

According to Purnamawati (2015), Susanto (2017), Afifah et al. (2017), and Shofiyyah et al. (2022) problem-based learning (PBL) is a learning model that is suitable for biology material because it is able to make students play an active role in solving real problems, increase understanding, develop collaboration skills and increase students' knowledge. Izzati (2017) also believes that PBL has a learning impact that is educational, fun, and has better performance compared to teaching in general. PBL is actively able to solve complex problems so that students are able to understand the lesson content to discover, improve and develop new knowledge in learning activities.

In previous research, Mutia et al. (2022) on the topic of learning to develop fluid e-modules for students' conceptual understanding has proven that e-modules can improve high school students' conceptual understanding with average pretest and posttest scores of 58.42 and 78 respectively. Awami et al. (2022), Rahmawati et al. (2022), and Laili et al. (2023) explains that the use of e-modules in problem based learning with effectiveness results data shows a significance value (2-tailed) of 0.000 < 0.15 so that the use of e-modules that have been developed is effectively used during the learning process for students' understanding of concepts.

The use of e-modules in problem-based flipped classrooms is an effective solution for increasing students' learning independence and understanding of concepts (Setiadi, 2017). Based on the results of the questionnaire, 80% of students agreed to use digital media because they were considered capable of increasing learning independence, e-modules are flexible because students can learn anytime and

anywhere. According to Imansari (2017), students can learn at their own pace and this can help them understand the concepts of the material better. Apart from being flexible, the e-module is also designed with interactive elements equipped with videos, animations and quizzes. This can help explain complex material in a way that is easier to understand. According to Efendi (2021), Kurniawan et al. (2021), Lestari (2022), and Kemdikbud (2024) the use of e-modules in the learning process can increase students' learning independence. The use of the e-module is able to provide students with the opportunity to learn independently, be able to take the initiative to read, be able to save learning time and the e-module can be accessed many times. According to Faridah et al. (2017), Capone et al. (2017), Zheng et al. (2020), Purwoto et al. (2022), and Jalinus et al. (2020) e-modules have advantages over printed books because they are interactive and considered more interesting because they are equipped with pictures, video and audio. According to Mulyadi et al. (2016), e-modules also have an instant feedback feature that allows students to immediately understand the material and helps them prepare better in class. Developing an interesting and innovative e-module certainly requires a teaching medium that can help improve the quality of learning.

In the learning process the role of the teacher is very important in choosing the right teaching method to create effective and flexible learning. There are several teaching methods that teachers can use to deliver learning material to students, such as lecture methods, group discussions, cooperative learning, project-based learning and technology-based learning and the flipped classroom. In developing the e-module, the flipped classroom learning method was used. According to Chen (2013), the flipped classroom is a flexible learning method that allows students to study anytime and anywhere. With the flipped classroom, it is hoped that students will be able to learn the material before class starts.

Method

Type of research and development Research and Development (R&D) is a research and development method to produce new products through the development process and test the effectiveness of the product (Sugiyono, 2017). Research activities are integrated throughout the product development process. The products produced in learning tools are:e-module in problem-based learning (PBL) with the flipped classroom learning method on biotechnology material.

The development model uses a model developed by Dick & Carey (1996), namely analysis (analyze), design, development, implementation and evaluation (ADDIE) (Cahyadi, 2019). The selection of the model was based on the consideration that the model was developed systematically and based on the theoretical basis of learning design. This model is structured programmatically with systematic sequences of activities in an effort to increase learning independence and understanding of concepts related to teaching materials that suit the needs and characteristics of students.

The analysis stage aims to analyze the need for learning independence and students' understanding of concepts. The research stages carried out were observations and interviews with Biology Teachers and analysis of the needs of class XII students at SMAN 1 Cangkringan. The purpose of the observations and interviews carried out was to determine students' learning models, the types of learning resources used, and analysis of learning outcomes. Therefore, further analysis is carried out to determine the needs and abilities of students, such as curriculum analysis and student analysis.

Design Stage

The design stage aims to design the e-module and research instruments. This stage begins after determining the learning objectives by selecting the right media to present Biology learning material in the biotechnology sub-material. The learning teaching materials are in the form of e-module learning tools in problem-based learning (PBL) with the flipped classroom learning method.

Development Stage

The development stage is carried out after the learning media developed has been completed and is ready to be used. The next learning media assessment includes several assessments, namely validation by material experts, validation by media experts, assessment by field practitioners or Biology Teachers. Comments and suggestions provided by validators are used to revise the learning media being developed. Once it is stated that the learning media is appropriate, the learning media can be implemented for students.

Implementation Stage

The implementation stage is a trial stage on learning media that has been declared suitable for students. The trial was carried out in Biology learning, biotechnology material. All students were given a questionnaire to see the students' responses after using the learning media developed.

Evaluation Stage

The evaluation stage is the final stage for revising the learning media developed. The evaluation stage is carried out in two forms, namely formative and summative. Formative is carried out at every stage, from the analysis stage to the implementation stage. The purpose of the evaluation is to see small errors in the media being developed, while the summative is carried out at the end of the research activity, namely to see the quality and suitability of the product as a whole based on input from validator experts and student assessments.

Product Trial Design

Product testing is an assessment activity by experts and research subjects on the product being developed and the impact after implementing the product. The trial stage is carried out to perfect the product being developed.

Trial Design

Trials were carried out to improve and obtain feedback on the quality of the e-module being developed. The following are the stages of product testing in this research.

Feasibility Trial

The feasibility trial of the e-module in problem-based learning (PBL) using the flipped classroom learning method on biotechnology material was tested by an expert lecturer in Biology Education at FMIPA UNY with doctoral qualifications (Doctoral/Phd) who had a good understanding of learning media and biotechnology material. The validation results were obtained from the assessment of media experts and material experts who will be used as a reference in the initial phase of revising the biotechnology e-module.

Practicality Trial

The practicality trial involved Biology subject teachers as educational practitioners at high school level and phase F students. Teachers assessed the practicality of the e-module on biotechnology material which was developed based on material, language and media aspects. Phase F students provide several assessment aspects, namely ease of understanding the material, ease of use, and attractiveness of appearance. The results of the practical trials were used as a reference for revising the e-module that was developed and implemented in field trials.

Field Trials

These trials were carried out with limited trials and wide-scale trials (field trials). The limited-scale trial aims to assess the learning media and then improve it based on students' responses and comments before implementing it in a wide-scale trial. This limited scale trial was tested on 30 students who would study biotechnology material in class XII using random sampling which aimed to determine the validity and reality of the questions.

Field trials (wide scale trials) were carried out involving all students in one class who used smartphones in class XII high school. The trial was carried out by providing test questions and student response questionnaires to see the effect of use on students' learning independence and understanding of concepts. The research method for large-scale trials uses Nonequivalent Control Group Pretest and Posttest (Table 1).

Table 1. Wide Scale Trial Design

Group	Pretest	Treatment	Posttest
Experiment	X1	O1	Y1
Control	X2	O2	Y2

(Source: Research, 2024)

Information:

X1 : Pretest of Understanding Concepts and Initial Questionnaires Learning Independence Experiment Class before Implementing E-Module in PBL with Flipped Classroom Learning Method

X2 : Pretest of Understanding of Concepts and Initial Questionnaire for Control Class Learning Independence before undertaking Biotechnology Learning with the 5M Model + Modules

Y1 : Posttest of Understanding of Concepts and Final Questionnaire of Experimental Class Learning Independence after Implementing E-Module in PBL with the Flipped Classroom Learning Method

Y2 : Posttest of Understanding of Concepts and Final Questionnaire for Control Class Learning Independence after studying Biotechnology with the 5M + Module Model

O1 : Biotechnology Learning in the Experimental Class Using E-Module in PBL with the Flipped Classroom Learning Method

O2 : Biotechnology Learning in Control Classes Using Textbooks or LKS

Test Subjects

Subjects for testing products developed in research, material experts are lecturers who have expertise in mastering biotechnology material and learning tools, such as teaching modules, E-Modules, etc. Media experts are lecturers who have expertise in the field of design and expertise in the field of technology to help improve the products developed by researchers. The Biology teacher at the school where the research was conducted was the one who assessed the practicality of

the e-module in PBL using the flipped classroom learning method developed by the researcher. Students of SMAN 1 Cangkringan who are studying biotechnology. The sample was selected using random sampling, so that a random sample was obtained, namely Class XII MIPA 2 as the control class and Class XII MIPA 1 as the experimental class. Each class has 30 students.

Data Collection Techniques and Instruments
Data Collection Technique
Observation

Observation in research acts as an observer in the process of carrying out large-scale trials in the control class and experimental class.

Interview

Interview techniques are used to collect data in preliminary studies by finding problems that must be researched and knowing the needs of research subjects (Sugiyono, 2017). In the research, the subjects were Biology subject teachers and curriculum representatives in the preliminary study carried out by the researchers. Interviews were conducted to determine the condition of the school, the needs of students and the availability of facilities and infrastructure.

Questionnaire

A questionnaire is a data collection technique by providing questions for respondents to answer to determine students' needs.

Test

This research uses data originating from test and non-test instruments which will be addressed to students as respondents. The non-test instruments are in the form of learning independence questionnaires and the test instruments are questions about students' conceptual understanding.

Data Collection Instrument
Interview Guide

The interview sheet contains questions that aim to identify learning activities carried out by teachers and students in general. Interviews were conducted to identify the curriculum, teaching materials, learning models, and students' use of facilities.

Questionnaire Instrument

Questionnaire instruments are used to collect data at the analysis, development and implementation stages. The questionnaire instruments used are as follows.

Student Needs Questionnaire Sheet

The needs analysis sheet is used to obtain information from students regarding learning experiences in Biology learning and the learning resources used by students.

Material Expert Assessment Questionnaire Sheet

The material expert assessment sheet was used to obtain validity results and input from the assessment results regarding the e-module in PBL using the flipped classroom learning method on biotechnology material. The assessment is carried out on several aspects, namely the appropriateness aspect of the material, the presentation aspect of the material, and the language aspect. The assessment uses a Likert scale in the scoring guidelines.

Media Expert Assessment Questionnaire Sheet

The media expert assessment sheet was used to obtain validity and incorporate the results of the e-module assessment into PBL using the flipped classroom learning method on biotechnology material. The assessment is carried out using several aspects, namely cover, content and presentation. This assessment uses a Likert scale in the scoring and filling guidelines.

Biology Teacher Assessment Questionnaire Sheet

The Biology Teacher assessment questionnaire sheet was used to obtain an assessment of the practicality of the e-module in PBL using the flipped classroom learning method on biotechnology material. Assessment is carried out based on several aspects, including: material/content, construction aspects, and language aspects. Assessment to obtain Biology Teacher responses uses a Likert scale in the scoring and filling guidelines.

Student Assessment Questionnaire Sheet

The assessment questionnaire sheet was used to obtain responses from class XII MIPA students after using the e-module in PBL with the flipped classroom learning method on biotechnology material. Assessment is carried out based on several aspects, including: programming aspects, content and appearance aspects. Assessment to obtain student responses uses a Likert scale in the scoring and filling guidelines.

Student Learning Independence Questionnaire Sheet

The learning independence questionnaire sheet was used to determine the differences in learning independence before and after learning in the large-scale trial phase in the control class and experimental class. Assessment is carried out based on several aspects, including: being diligent in carrying out tasks, being tenacious when facing difficulties or not giving up

easily, feeling bored with routine and unvaried tasks, enjoying working alone, defending opinions, and enjoying finding and solving problems new.

Learning Implementation Observation Sheet Instrument

The learning implementation observation sheet is used to obtain information about the percentage of learning implementation based on observer observations during large-scale trials in the control class and experimental class. Aspects observed in the experimental class followed teaching modules in the PBL learning model with the flipped classroom learning method and the control class used teaching modules with the 5M learning model. The observation sheet uses the Guttman scale in scoring guidelines and fills in answers with "yes" and "no".

Concept Understanding Test Instrument

The test sheet is used to determine differences in students' conceptual understanding before and after learning in the field trial phase in the control class and experimental class. The test sheet was assessed using QUEST to determine the validity and reliability of the instrument.

Data Analysis Technique

The data analysis technique was carried out qualitatively by analyzing responses and research subjects in the form of comments, suggestions and information. This data analysis technique can also be carried out quantitatively by analyzing responses from research subjects in the form of scores that refer to the assessment scale used.

Needs Analysis

Teacher needs analysis was carried out based on the results of observations and interviews by the Biology Teacher at SMAN 1 Cangkringan. The interview results were analyzed by drawing conclusions from the Biology Teacher's answers. Analysis of student needs was carried out based on the results of filling out questionnaires by students using descriptive quantitative methods. This method is used to describe, research and explain something studied as it is, and draw conclusions from phenomena that can be observed using numbers.

Table 2. Conversion of Quantitative Data into Qualitative Data

Score Intervals		Criteria
Li + 1.5 Sji ≤ x ≤ Li + 3Sji	3.25 ≤ x ≤ 4	Very good
Li + 0 Sji ≤ x ≤ Li + 1.5 Sji	2.5 ≤ x ≤ 3.25	Good
Li - 1.5 Sji ≤ x ≤ Li + 0 Sji	1.75 ≤ x ≤ 2.5	Enough
Li - Sji < x ≤ Li - 1.5 Sji	1 ≤ x ≤ 1.75	Not enough

Information:

Li = Mean Ideal = ½ (ideal max score + ideal min score) = ½ (4+1) = 2.5

Sji = Ideal Standard Deviation = 1/6 (ideal max score– Score min ideal) = 1/6 (4-1) = 0.5

X = Actual Score (achieved score)

From the results of calculations using the formula above, it is used to change the initial data into four categories of data, namely very good, good, sufficient and poor. Data analysis is determined using the frequency distribution formula as follows:

$$P = \frac{F}{N} \times 100\% \quad (1)$$

Information:

P = Percentage

F = Respondent's Answer Frequency

N = Number of Respondents

Product Feasibility and Practicality Test

Feasibility analysis is used to determine the feasibility of e-modules in problem-based learning (PBL) with the flipped classroom learning method which was developed based on the assessment of material experts and media experts. The practicality of the analysis product is based on assessments by teachers and students. Assessment of product feasibility and practicality is carried out using a Likert scale.

Then calculate the criteria score for the resulting learning product by determining the interval distance based on the highest and lowest scale along with the number of classes. In detail it can be explained as follows:

Highest score = 4 (Very Decent)

Lowest Score = 1 (Not Eligible)

Number of Classes = (Very Eligible – Not Eligible)

Interval Distance Formula

$$\frac{\text{High score} - \text{Low score}}{\text{Number of class}} = \frac{4-1}{4} = 0.75 \quad (2)$$

From the interval distance results above, the following is a table of learning product score categories xi as the average of each item.

Table 3. Average Score Category

Average Score	Category
3 ≤ xi ≤ 4.00	SL (Very decent)
2.50 ≤ xi ≤ 3.24	L (Decent)
1.75 ≤ xi ≤ 2.49	KL (Less Appropriate)
1 ≤ xi ≤ 1.74	TL (Not Eligible)

After getting the average data for several aspects, then convert the average score to a value of 100 using the formula:

$$\text{Value of each aspect} = \frac{\text{Average score}}{\text{Maximum score}} \times 100 \quad (3)$$

According to Agustin et al. (2018), after getting the average score for each aspect, the data was interpreted using the product feasibility and practicality assessment criteria (Table 4 and Table 5).

Table 4. Product Feasibility Assessment Criteria

Quality Score	Score	Score
81-100	Worthy	Not Revised
60-80	Decent Enough	Partial Revision
30-60	Not Worth It	Partial Revision and Reassessment of Theory
≤ 30	Not feasible	Total Television

Table 5. Product Practicality Assessment Criteria

Assessment Score	Category
81-100	Very Practical
60-80	Practical
30-60	Enough
≤ 30	Less Practical

Implementation of Learning

The implementation of learning uses the results of observer observations of the implementation of learning carried out in control and experimental classes. Data analysis was carried out quantitatively by referring to the observer's assessment based on a scale with "yes" or "no" categories on the observer sheet. The learning implementation formula is as follows:

$$\frac{\sum \text{Implemented Learning Syntax}}{\text{Total Number of Learning Syntaxes}} \times 100\% \quad (4)$$

Validity and Reliability

Validity aims to state the level of accuracy of a measuring instrument in measuring an instrument. A measuring instrument is declared valid if the measuring instrument is truly capable of providing information that corresponds to what is being measured. The validity test uses the Quest program. The criteria used for item validity are if the item has an INFIT MNSQ value in the range of 0.77-1.30, the item is considered fit.

Reliability is related to the consistency of a measuring instrument in research in the form of an instrument for learning independence and understanding concepts. An instrument is said to be reliable if it gives the same results repeatedly during repeated measurements. Reliability uses the Quest program to see the measurement error values presented in the summary of case estimate (Yanto et al., 2019). The reliability of the instrument is then categorized with the condition that if the reliability value is ≥ 0.70, then the instrument has low reliability (Sugianto et al., 2020).

Analysis of the Effectiveness of the Biotechnology E-Module on Learning Independence and Concept Understanding

Descriptive Statistical Analysis

Descriptive statistical data analysis using learning independence questionnaires and concept understanding instruments in the pretest and posttest phases in wide-scale trials in control and experimental classes. This analysis uses the Excel application. The formula used includes the average value, total value, standard deviation, lowest value, and highest value.

The next analysis using the n-gain score formula aims to classify the criteria for learning independence instruments and students' conceptual understanding (Table 6).

Table 6. N-Gain Interpretation Criteria

Mark	Criteria
g > 0.70	Tall
0.30 < g ≤ 0.70	Currently
g ≤ 0.30	Low

(Source: Yanto et al., 2019)

$$\text{N} - \text{gain formula} = \frac{\text{Sf} - \text{Si}}{\text{Smax} - \text{Si}} \quad (5)$$

Information:
g = Normalized Gain Score
Sf = Posttest Score
Si = Pretest Score
Smax = Maximum Score

Inferential Statistical Analysis

Inferential statistical analysis using questionnaires for learning independence and concept understanding instruments. Wide scale trials in the control class and experimental class using pretest and posttest. Concept understanding data is ratio data that can be analyzed using parametric inferential statistics. If these parametric requirements are met, then the learning independence data uses interval data. The influence of the dependent variable on the research was analyzed using Multivariate Analysis of Variance (MANOVA) statistical analysis.

Prerequisite Test

Normality Test

The normality test is a data analysis to determine the increase in learning independence and understanding of concepts. using the N-Gain value. The N-Gain value is a comparison of the gain score obtained by students with the highest possible gain score obtained by students (Riyanti, 2021).

Homogeneity Test

The homogeneity test is a test used to determine that the research data for each group comes from populations that do not differ much in diversity or that the samples used come from homogeneous populations (Sundayana, 2015; Wahjusaputri & Purwanto, 2022).

Multicollinearity Test

The multicollinearity test aims to test whether the two dependent variables have a very strong correlation or not. If the Pearson correlation value is <0.08, it can be concluded that multicollinearity does not occur.If the Pearson correlation value is > 0.08, it can be concluded that multicollinearity has occurred.

Hypothesis Testing

Hypothesis testing was carried out to obtain final data as a basis for determining conclusions, how effective is the e-module in PBL with the flipped classroom learning method in increasing students' learning independence and understanding of concepts using MANOVA statistical analysis.

Results and Discussion

Research and development (R&D) research which produces the final product in the form of an e-module in problem-based learning (PBL) with method flipped classroom learning on biotechnology material. The aim of the resulting learning media is to determine the feasibility, practicality and effectiveness of the product through material expert validators, media experts, Biology Teachers and student responses to the e-module developed to improveindependent learning and understanding of conceptsPhase F students at SMAN 1 Cangkringan Yogyakarta. The research was conducted on the control class and experimental class.

The first stage of e-module development in problem-based learning (PBL) withmethodIn flipped classroom learning, a preliminary study was carried out by collecting teacher interview information and distributing questionnaires regarding student needs regarding Biology learning. The next activity is curriculum analysis, namely ATP, CP and Teaching Modules with the learning models and methods used by teachers in the classroom learning process. The results of the preliminary study show that the learning process in class only uses textbooks and worksheets, much of the material presented is difficult to understand and the book presentation is less interesting, making students bored and bored in learning.

The second stage, designing a learning model by developing products that are validated by material expert validators, media and practitioners. The validation results from media experts obtained an average score of 4.00 with 100 conversions in the very feasible category. The conclusion from these results shows that the quality of the e-module in problem-based learning (PBL) is goodmethodThe flipped classroom learning developed can be used in the Biology learning process on biotechnology material. The results of the next validation were material experts who got an average score of 3.8 with a conversion of 95 in the very feasible category. The conclusion from these results shows that the e-module in problem-based learning (PBL) withmethodThe flipped classroom learning developed on the material presented is in accordance with the learning objectives and learning design. Suggestions and input by expert validators are used as references and improvements to e-modules in problem-based learning (PBL) with method flipped classroom learning so that implementation can be used optimally.

The third stage, after the e-module is declared feasible, a readability test is carried out. The results of the readability test obtained an average score of 3.87 with a conversion of 97 in the very feasible category. The students who were tested were class XII MIPA 1 as an experimental class totaling 30 students. The readability test results show that the e-module in problem-based learning (PBL) with the flipped classroom learning method can be used in the learning process.

The first implementation stage, test questions on understanding concepts with multiple choice questions which were tested on 60 class XI students at SMAN Cangkringan. 30 MIPA 2 class students as the control class and 30 MIPA 1 class students as the experimental class. The comprehension test at the implementation stage aims to see students' ability to understand concepts. The results of the instrument trial were analyzed using the Quest program with the aim of finding out the validity and reliability of the questions. The results of the trial showed that 9 questions were valid and 6 questions were invalid. Invalid question items were consulted with the Biology Teacher. After the Teacher stated that the questions were suitable to be used to test students' understanding, the researchers used 15 multiple choice questions to test students' understanding of concepts in biotechnology material. Analyze the reliability results of the questions by getting a summary of case estimate score showing a value of 0.69 in the very reliable category.

The research phase was carried out at SMAN 1 Cangkringan on phase F students in class XII, Science 1 as the experimental class and Science 2 as the control class. The learning design control class uses 5M (observing, asking, gathering information, associating and communicating). The 5M learning model is a learning model that teachers usually use in the teaching process with the help of textbooks and worksheets. The experimental class uses the PBL learning model

(orienting students to problems, organizing students to learn, guiding individual and group investigations, developing and presenting results, and analyzing and evaluating the problem solving process) with the help of e-modules with the flipped classroom learning method.

The results of the observer's observations and recording of the implementation of the learning obtained 100% implementation results at the two learning meetings that took place. Learning goes well and is in accordance with the learning design in the teaching module. According to Ahmad et al. (2021), the learning process can be said to be running smoothly if the teacher has implemented the learning model even though the indicators for implementing the learning model have not been implemented well overall.

Statistical data results for understanding concepts in the experimental class and control class. The average score in the pretest experimental class was 66.27 and the average posttest score in the experimental class was 86.00. Then the average score for the control class on the pretest was 68.17 and the average score for the control class on the posttest was 80.47. The conclusion from the data analysis results was that the total posttest scores had a higher value compared to the control class and experimental class. E-module in problem-based learning (PBL) with method Flipped classroom learning has an effect on increasing students' understanding of concepts.

After conducting a practicality test on the emodule product in problem-based learning (PBL) with method flipped classroom learning. The test results will be analyzed using the MANOVA test with the help of SPSS. First, the SPSS results in the normality test in the Test of Normality section show that the control class and experimental class values are > 0.05, that is, the distribution of the data is normally distributed. Second, the homogeneity test in the Test of Homogeneity of Variance section shows a sig valueindependent learning and understanding of conceptsshows > 0.05, namely the data distribution comes from a homogeneous population.

Prerequisite Test

Normality Test

The results of the normality test on the pretest and posttest results of the control class and experimental class on increasing learning independence showed that in the experimental class with the One-Sample Kolmogorov-Smirnov Test the value was significant (P > 0.05), so the value was normally distributed.

Homogeneity Test

The results of the homogeneity test for understanding the concept show that the Significance (Sig.) Based on Mean is 0.860 > 0.05, so it can be concluded that the variance of the experimental class posttest data and the control class posttest data is not the same or heterogeneous. The results of the homogeneity of learning independence test show that the Significance (Sig.) Based on Mean is 0.058 > 0.05 so it can be concluded that the variance of the experimental class posttest data and the control class posttest data is not the same or heterogeneous.

Variance Matrix Homogeneity Test

Based on the homogeneity test of the variance matrix based on the Box's M formula, the results showed that the significance of the pretest and posttest data was p > 0.05. Conclusion from the homogeneous variance-covariance matrix regarding the independent variables.

Multicollinearity Test

The final test result is a multicollinearity test using the person correlation formula (p > 0.05), so it can be concluded that the variance-covariance matrix is homogeneous for the independent variables.

Manova Test

The results of the prerequisite tests can be concluded that MANOVA parametric inferential statistics can be carried out. The results of the MANOVA analysis show that the sig value in the Pillai's Trace, Wilks' Lambda, Hotteling's Trace and Roys Lasgest Root formulas is > 0.05, in this table it can be concluded that the hypothesis (Ha) is rejected: there is an influence of differences in conceptual understanding and independence Simultaneous student learning is significant for students who use e-modules in PBL with a flipped classroom compared to students who use printed books with 5M learning. (H0) is accepted: there is no effect on differences in students' simultaneous understanding of concepts and learning independence for students who use e-modules in PBL with a flipped classroom compared to students who use printed books with 5M learning and alternative hypotheses.

Conclusion

Based on research on the development of e-module learning products in problem-based learning (PBL) using the flipped classroom learning method that has been implemented, it can be concluded that: E-module products in problem-based learning (PBL) with method Flipped classroom learning is suitable for use in Biology learning activities on biotechnology material; Use of e-module products in problem-based learning (PBL) with method Practical flipped classroom learning is used in Biology learning activities on biotechnology material; Application of e-module products in problem-based learning (PBL) with method Flipped classroom learning

is effectively implemented in increaseindependent learning and understanding of conceptslearners.

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