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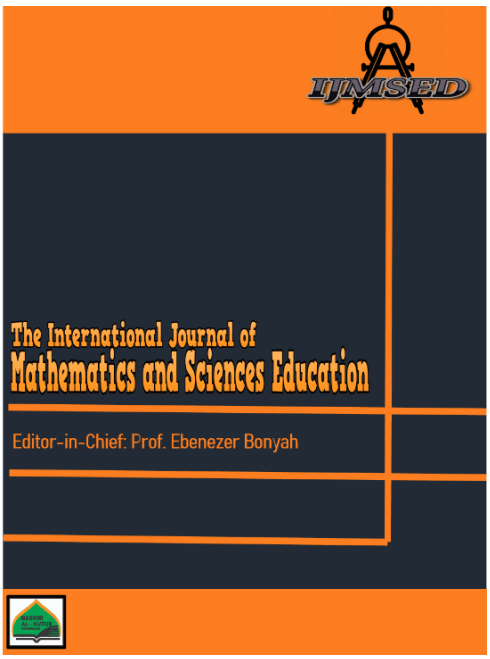

Developing Papuan cultural contextual E-Module learning devices in linear programs to improve students' mathematical problem-solving skills

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Abstract
Using e-modules in learning has improved students' mathematical problem-solving abilities. However, the design of e-modules that integrate local culture is still rarely developed. This study aims to create a contextual e-module that reflects the culture of the Papuan community at State Vocational School I Agribusiness and Agrotechnology Nduga. This study used research and development (R&D) methods with the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The participants in this study included material, language, media experts, teachers, and eleventh-grade students. Qualitative data were collected through respondent suggestions, and quantitative data were obtained through validation questionnaires and student testing. The analysis results showed that the Papuan cultural contextual e-module was valid, with percentages of 77.33% from material experts, 73.33% from language experts, and 68.88% from media experts. Teacher and student responses showed excellent practicality, with averages of 93.33% from teachers and 85.28% from students. In addition, the pre-test and post-test results showed a significant improvement in students' mathematical problem-solving abilities, with the KKM achievement level reaching 95.5% and a significance value (Sig. 2-tailed) < 0.001. Therefore, the contextual e-module based on Papuan culture can be an effective supplementary teaching material in mathematics learning, especially in linear programming material.

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1. Introduction

Mathematics education has long been recognized as a fundamental pillar in developing students' cognitive abilities, problem-solving skills, and critical thinking. Mathematics is an important subject throughout the education system (Holm et al., 2024). This is because mathematics learning is not only crucial as a foundation and tool to train students in critical, logical, systematic, creative, and independent thinking, but also in developing contextual problem-solving skills (Zulmaulida et al., 2021). This statement aligns with the views of Bakker et al. (2021), who emphasize the essential role of mathematics in overcoming challenges in various aspects of life. Thus, mathematics education is vital at all levels of education because it fosters critical, logical, systematic, and creative thinking, as well as the development of contextual problem-solving skills, which are essential for facing life's challenges.

Problem-solving ability is one of the key aspects of mathematics learning (Santos, 2024; Taufan et al.,2024) because it strengthens the understanding of mathematical concepts and enhances creativity. However, at SMK Negeri I Agrobisnis dan Agroteknologi Nduga, the mathematical problem-solving ability of students remains a significant concern, particularly in solving word problems. This is attributed to several factors: lack of teacher creativity in designing learning materials, the use of inappropriate teaching methods, limited utilization of technology, teaching materials that are less relevant to students' lives, and unengaging teaching materials. Moreover, face-to-face learning time has not been maximized due to frequent regional conflicts. Furthermore, the mathematical literacy of students at SMK Negeri I Agrobisnis dan Agroteknologi Nduga is still lacking, making it difficult for them to solve word problems. On the other hand, solving contextual problems requires students to have strong mathematical literacy (Almarashdi et al., 2023).

One way to measure students' mathematical literacy is through The Program for International Student Assessment (PISA) (Poernomo, 2021). PISA test results from 2000 to 2015 indicated that Indonesian students' mathematics scores were still low (Yusmar et al., 2023). To improve the quality of mathematics education in Indonesia, Ministerial Regulation No. 19 of 2005, Article 20, Paragraph 1, states that teachers must be able to develop innovative teaching materials (Restiana et al., 2022). Therefore, educators must be creative in designing engaging teaching materials that are relevant to students' needs to facilitate understanding. Based on an analysis of the learning needs of students and teachers at SMK Negeri I Agrobisnis dan Agroteknologi Nduga, located in Nduga Regency, Papua Pegunungan Province, it was found that both students and teachers require additional teaching materials in the form of contextual electronic modules (e-modules) that reflect Papuan culture, especially for the linear programming material.

The development of a contextual e-module based on Papuan culture is an appropriate solution to the challenges faced by teachers and students at SMK Negeri I Agrobisnis dan Agroteknologi Nduga. The school has already provided adequate facilities, such as a computer lab with free internet access and 4G internet connectivity. Moreover, almost all students own mobile phones, making digital and interactive learning methods feasible. According to Gufran et al. (2020), e-modules are electronic learning media accessible via computers, gadgets, or other software. E-modules offer flexibility in presenting learning materials because they can be accessed easily without spatial limitations (Marlena et al., 2022). In line with previous research, Lestari et al. (2022) demonstrated that e-modules positively impact learning linear programming. Additionally, Rahman's (2023) research shows that e-modules effectively improve student learning outcomes. E-modules have been proven to significantly increase accessibility, flexibility, and learning effectiveness (Bhat et al., 2022).

However, the development of e-modules will be more effective if it is integrated with students' local culture. This is consistent with Russell et al. (2022), who argue that learning materials should incorporate methods and content relevant to local culture, as this can enhance the effectiveness of mathematics education. Mathematics is not merely a collection of formulas and calculations but a universal language that helps us understand the world around us (Solehah et al., 2023). Integrating local culture into learning reflects the community's identity and allows students to understand mathematical concepts more meaningfully. It also enables students to connect mathematics to real-life situations, thereby increasing their motivation and overall understanding.

This study differs from previous studies in three main ways. First, this study will be conducted in a conflict area. Second, while previous studies only developed valid, practical, engaging, and effective interactive e-modules without considering local culture, this study will focus on developing e-modules that integrate local culture. Third, this study specifically focuses on developing contextual e-modules incorporating Papuan culture. Therefore, this research aims to develop a contextual e-module based on Papuan culture for linear programming as a step toward improving students' mathematical problem-solving abilities.

2. Method

Study This is research and development (R&D), using the ADDIE development model. *Research and development* (R&D) is a systematic and structured approach used to create, test, and refine new products or systems (Mesra, 2023). In the context of education, R&D aims to develop innovative and effective teaching materials, curricula, or educational technologies (Okpatrioka., 2023). Meanwhile, the

ADDIE development model is a systematic framework used to design and develop teaching materials. The stages of the ADDIE model are *Analysis*, *Design*, *Development*, *Implementation*, and *Evaluation* (Spatioti et al., 2022).

Stages study

a. Analysis

At the analysis stage, several methods can be used, such as interviews, observations, questionnaires, and literature studies. The analysis stages are divided into; (1) Analysis of existing problems aims to formulate statements related to the problem, identify what causes the problem, and find solutions to overcome existing problems. (2) Subject analysis is an important step in developing Papuan cultural contextual e-modules. (3) Analysis of KI, KD, and indicators is carried out so that developers design Papuan cultural contextual e-modules according to curriculum needs and ensure that the material presented can help students achieve the expected competencies. (4) Analysis of student characteristics is important to design content according to student learning needs and profiles. Developers can create Papuan cultural contextual e-modules that are more responsive, increase student engagement, and improve overall learning effectiveness. (5) Analysis of the learning environment includes understanding technological infrastructure, internet access, and availability of learning resources. Non-technical factors such as culture, language, and socio-economic characteristics are also considered to adjust the learning approach.

b. Design

At this stage, it is divided into (1) Choosing the form of message delivery, the media chosen is assisted by technology such as *mobile phones*, computers, and the like. (2) Creating an instructional strategy, the instructional strategy used in delivering linear program material is a Papuan cultural contextual approach based on problems, which involves the integration of mathematical concepts with the context of everyday life of the Papuan people to make learning more relevant and meaningful. (3) Mapping the media elements that will be used is important to conduct analysis and mapping of the materials that will be presented in the Papuan cultural contextual e-module to get a general picture of the media components that will be used for each competency targeted, thus facilitating the next design process. (4) Compiling a systematic e-module, carried out to ensure that the content is delivered clearly and effectively.

***c. Development* (Development)**

Contextual e-module development stages Papuan culture is an important phase in the preparation of materials, where all components are carefully arranged according to the initial design. This process involves a series of activities, such as; (1) Collecting materials, closely related to the characteristics and needs of students such as materials, videos, and images of Papuan culture. All materials are combined in a *Microsoft Word file* before being designed on *Heyzine Flipbooks*. (2) Media creation is the stage where all the necessary components are created and combined using *Heyzine Flipbooks*. The creation is carried out following the flowchart, navigation structure, and storyboard that have been planned at the design stage.

d. Implementation

At this stage, the product results that have been developed are then tested on research subjects to determine the validity, practicality, and effectiveness of the Papuan cultural contextual e-module.

1) Implementation design

At this stage, several trial steps were carried out, such as; (1) trials by experts, namely material experts, language experts, and media experts, the results of these expert trials are input for revisions so that in the end a valid product is obtained. (2) Limited trials, testing is carried out based on reviews from several respondents, including; subject teacher trials, individual trials, small group trials, and limited field trials. This trial was carried out to see the practicality and effectiveness of the Papuan cultural contextual e-module.

2) Implementation subject

The subjects of the implementation of the Papuan cultural contextual e-module consist of experts, teachers, and students. The experts involved come from various universities, namely Madura University, Mataram University, and Open University, with a minimum educational qualification of Doctorate (S3). Meanwhile, the teachers and students who are the subjects in this implementation come from SMK Negeri I Agrobisnis dan Agroteknologi Nduga. There are two teachers with a minimum educational

qualification of a bachelor's degree who teach mathematics. In addition, there are 35 grade XI students who were randomly selected consisting of 15 girls and 20 boys, in the even semester of the 2023/2024 academic year.

***e. Evaluation* (Evaluation)**

Evaluation is a process to see whether the product developed is successful and by initial expectations or not. The evaluation stage is carried out at each of the four previous stages and at the final stage of product development to determine the effectiveness of the product developed and after that, the dissemination of Papuan cultural contextual e-modules via the internet is carried out.

Data collection instruments

The instruments used in this study include: 1) student and teacher learning needs analysis sheets by implementing 2 sheets of student learning needs observation sheets. 3) Papuan cultural contextual e-module validation sheets; 4) Papuan cultural contextual e-module practicality sheets, there are two, namely student and teacher response questionnaires. 5) sheets *pre-test* and *post-test.* To measure the effectiveness of the Papuan cultural contextual e-module, which was carried out using interview, observation, and questionnaire distribution methods. Evaluation instruments are tools used by researchers to gather information (Maryani et al., 2022). The study of the development instrument was carried out by considering indicators that can assess the validity of e-module development (Aini et al., 2024).

Data analysis

This study uses qualitative and quantitative data analysis approaches. For the validity of the Papuan cultural contextual e-module, it is analyzed descriptively qualitatively and descriptively statistically. The level of validation of the learning device is determined by considering the assessment results of all validators. The analysis is carried out on all assessment items that have been carried out by each validator. To calculate the validation of each expert, the following formula can be used which is adapted from Akbar (2013:83):

$$Va = \frac{TSe}{TSh} \times 100\%$$

Information:

Va = expert Validation

TSe =total empirical score (validation results from validator)

TSh = maximum expected total score

The results of the percentage of validity levels are then interpreted in qualitative statements based on Table 1.

Table 1

Percentage of contextual validity of Papuan culture e-module

No	Validation Criteria	Validation Level
1	$80{,}01\% - 100{,}00\%$	Very valid (can be used without revision)
2	$60{,}01\% - 80{,}00\%$	Valid (usable but requires minor revision)
3	$40{,}01\% - 60{,}00\%$	Fairly valid (not recommended for use as it requires major revision)
4	$20{,}01\% - 40{,}00\%$	Invalid (should not be used)
5	$00{,}00\% - 20{,}00\%$	Invalid (may not be used)

Source: Akbar (2013:41)

Using a retrospective analysis of Papuan cultural contextual e-modules. Analysis of practical data on Papuan cultural contextual e-modules using the formula (Widoyoko, 2015);

$$p = \frac{total\ respondent\ score}{maximum\ respondent\ score} \times 100\%$$

The calculation results obtained are then grouped based on the practicality assessment criteria which can be seen in Table 2.

Table 2
E-Module Practicality Assessment Criteria

Percentage	Criteria
$25\%0 - 43\%$	Invalid
$44\% - 62\%$	Invalid
$63\% - 81\%$	legitimate
$82\% - 100\%$	Very valid

Source: (Widoyoko, 2015)

The analysis of the effectiveness of the Papuan cultural contextual e-module was carried out by comparing the results of the pretest and posttest using the t-test with SPSS to measure the increase in student understanding. The results of the student learning test were assessed based on the KKM mathematics completion score at SMK Negeri I Agrobisnis and Agroteknologi Nduga, which was 65, and the teaching material was said to be effective if the number of students met the KKM $\geq 75\%$. The calculation of student score values uses the following formula:

$$X = \frac{\text{number of students with grades} > 65}{total\ number\ of\ students} \times 10$$

3. Results and Discussion

The development of Papuan cultural contextual e-modules refers to the steps of developing the ADDIE model, so that the Papuan cultural contextual e-modules are valid, practical, and effective in improving student learning outcomes, especially in students' mathematical problem-solving abilities. In line with the research of Spatioti et al (2022), shows that the use of the ADDIE model in developing e-modules can produce valid, practical, and effective learning e-modules.

Results

a. Results analysis need

Based on the results of interviews and observations, it was found that the needs of teachers and students are additional teaching materials such as Papuan cultural contextual e-modules, in mathematics subjects on linear programming material. The student's statement was confirmed by the teacher who said that "the material that is quite challenging to teach is linear programming because it refers to the results of student grades which are always low on this material". Core Competencies (KI), Basic Competencies (KD), and indicators in this e-module are adjusted to the 2013 Curriculum. Then the characteristics of class XI students of SMK Negeri 1 Agrobisnis and Agroteknologi Nduga are generally 16-17 years old, many male students 19 children and female students 15 children, who come from Papuan tribes and diverse social statuses, and most students do not live with their parents due to the impact of regional security conditions. In addition, students' learning styles vary, some are kinesthetic, auditory, and visual, but more dominant visual.

The learning environment of SMK Negeri 1 Agrobisnis dan Agroteknologi Nduga is less conducive, there is a reduction in teaching hours due to conflict areas. Then the supporting facilities for the use of e-modules are available such as computer laboratories, free wifi for teachers and students, almost all students have Android phones, and 4G internet networks are also available in the area.

b. Results of designing contextual e-modules on Papuan culture

The Papuan cultural contextual e-module uses a technology-based information delivery method such as mobile phones, computers, and other digital tools, by applying a problem-based Papuan cultural contextual approach to linear program material, using *Microsoft Word media* to collect materials and then compiling the Papuan cultural contextual e-module using *Heyzine Flipbooks.*

c. Results of the development of contextual e-modules on Papuan culture

The Papuan cultural contextual e-module design is compiled using A4 paper with 3 cm right and left margins, 4 cm top margins, and 3 cm bottom margins, with double line spacing (2). Based on the scientific writing guidelines from the National Education Standards Agency (BSNP), this margin is considered optimal for the layout of educational documents (Ramli et al., 2022). The application of double spacing is also by the recommendations of instructional design experts who emphasize the importance of sufficient spacing to make it easier to read (Firman et al., 2022). This arrangement not

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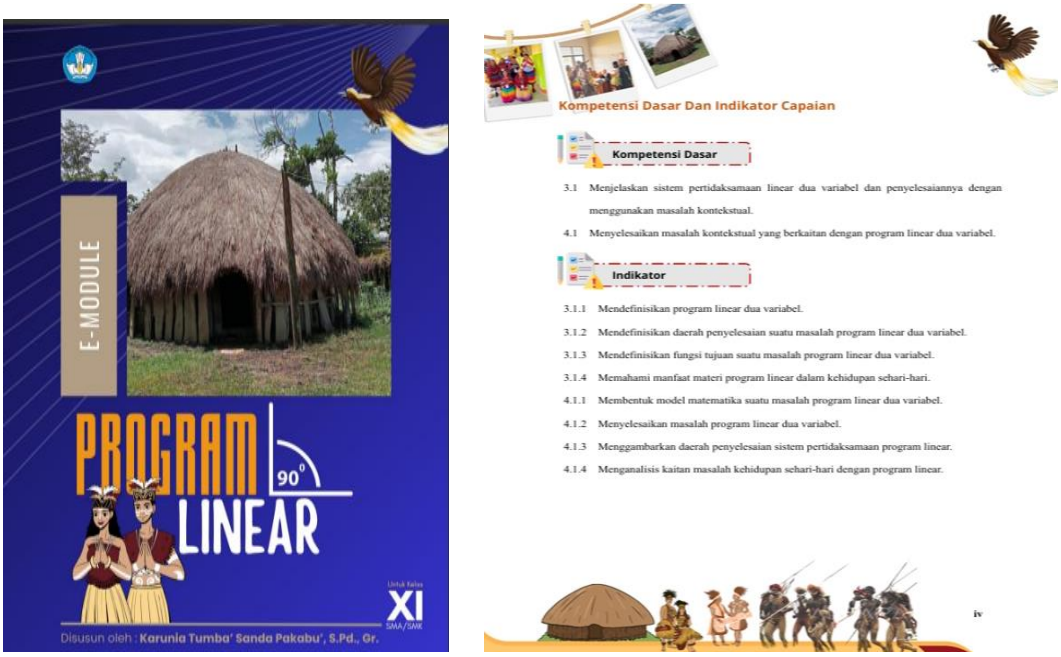
only beautifies the e-module but also increases user comfort in accessing and utilizing learning materials.

Times New Roman with a size of 12 pt. The use of this font is supported by various typography experts, as stated by Felici (2011) who stated that Times New Roman is one of the easiest fonts to read in various print and digital formats. In addition, Cai et al (2022) stated that 12 pt is the ideal size to ensure comfort in reading long texts. In addition, the selection of the background color of the material using white with black text aims to make the writing more comfortable, easy, and clear to read. This opinion is supported by research conducted by Putra et al (2024) which states that the combination of a white background and black text provides optimal contrast, thereby increasing readability and reducing eye fatigue when reading for long periods.

The Papuan cultural contextual e-module contains integrated linear program material with in-depth Papuan culture in general. Each page of this e-module is decorated with illustrations that enrich Papuan culture, creating an interesting and authentic learning atmosphere. According to Hershman *et al* (2024), relevant and authentic visuals can strengthen students' cognitive processes, so that the material becomes more interesting and easier to remember. In addition, mathematics learning must also be integrated with local culture to maintain the relevance of cultural heritage in education (Abdulrahim et al., 2020). The presentation of material rooted in local culture provides significant academic benefits for students (Meaney et al., 2020). Local culture in learning also reflects student identity and enriches students' learning experiences. The use of a local cultural approach deepens students' understanding of mathematical concepts and relates them to everyday life, thereby increasing students' motivation and understanding (Maqsood et al., 2024).

Papuan cultural contextual e-modules not only present linear program material in text form, but are also equipped with explanatory videos that make it easier for students to understand the material and are adapted to various learning styles. According to Arruabarrena et al (2021), videos can improve understanding of complex concepts and provide variations in delivery methods, so they can meet various student learning styles. E-modules can integrate text, graphics, images, and videos, and can be accessed anytime and anywhere (Syahmani et al., 2022). In line with the opinion of Herlina et al (2024), electronic modules can convey information through images, videos, and animations so that they can increase students' understanding. The results of the development of the Papuan cultural contextual e-module are presented in Figure 1.

Figure 1
Structure of Papuan Cultural Contextual E-modules



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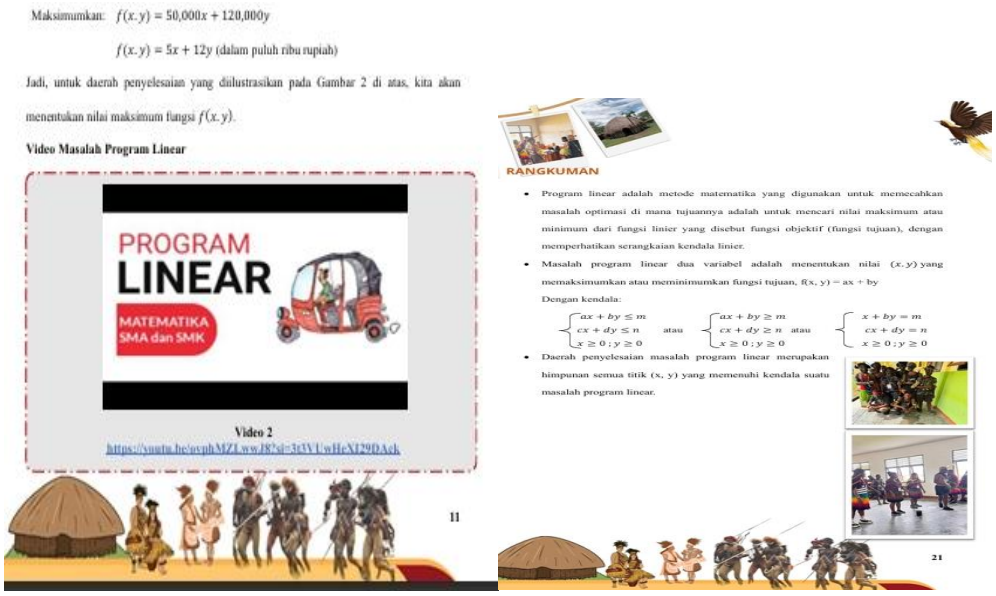


d. Results of the implementation of the Papuan cultural contextual e-module

1) Expert validation

The validation of the Papuan cultural contextual e-module involved three validators, namely material experts, language experts, and media experts. The purpose of this validation is to ensure quality, compliance, effectiveness, and user satisfaction by identifying potential errors, increasing effectiveness, and supporting decision-making in the development of e-modules (Mamakou et al., 2024). Before conducting the validation, the researcher first created a Papuan cultural contextual e-module validation questionnaire. The Papuan cultural contextual e-module validation questionnaire was first consulted with supervisors I and II to get input. After that, the questionnaire was validated by each expert to ensure its feasibility. Based on instructions and input from mentors and experts, the researcher then revised the questionnaire to ensure the suitability and quality of the e-module. Based on the validation results from the three experts presented as follows

2) Subject matter expert

Expert test materials are used as assessors of the content/material of the Papuan cultural contextual e-module that has been developed by researchers. The recapitulation of the Papuan cultural contextual e-module research hash from the material aspect is presented in Table 3.

Table 3
Recapitulation of E-Module Material Expert Assessment

No	Aspect	Total score
1	Quality of content/material	27
2	Learning	16
3	Feedback and adaptation	7
4	Motivation	8
Total score obtained		58
Maximum total score		75
Validity percentage		77.33%

Based on the presentation in Table 1, the score obtained from the assessment of the quality of the material or content of the Papuan cultural contextual e-module is 27, the score obtained for feedback and adaptation of the Papuan crocodile contextual e-module is 7, the score obtained for learning is 16, the score obtained for motivation is 8 so that the total score obtained is 58 out of a maximum score of 75. The percentage of validity of the material in the Papuan cultural contextual e-module is 77.33%. According to Akbar (2013:41) based on the criteria, 60,01% – 80%it shows that the e-module is valid and can be used by making minor revisions. So, the validation level of the Papuan cultural contextual e-module is valid and can be used by making minor revisions. So, the validation level of the Papuan cultural contextual e-module is valid and can be used with minor revisions. In addition, the validator

also provided responses and suggestions for teaching materials to improve the Papuan cultural contextual e-module material. There are suggestions and input that need to be improved; therefore, revisions were made before being tested on teachers and students. After revisions were made according to the validator's suggestions and input, the Papuan cultural contextual e-module can be tested on teachers and students. The following are responses and suggestions from the validator presented in Table 4.

Table 4
Expert Feedback and Suggestions for E-Modules

No	Feedback and suggestions
1	The module is very good, it is quite representative of Papua.
2	Please pay attention to the order of the material and the naming of the material in the lesson.
3	I am still confused between linear programming and understanding linear programming. Please reconsider what the name means.

3) Linguist

Validation test of language experts used as language evaluators on the Papuan cultural contextual e-module that has been developed by researchers. The recapitulation of the research results of the Papuan cultural contextual e-module from the language aspect is presented in Table 5.

Table 5
Recapitulation of E-Module Language Expert Assessment

No	Aspect	Total score
1	Easy	10
2	Communicative	4
3	Dialogic and interactive	8
4	Compliance	4
5	Chart	11
6	Use of Terms, Symbols, or Icons	7
Total score obtained		44
Maximum total score		60
Validity percentage		73.33%

Based on the presentation in Table 5, it shows that the score obtained from the assessment of the language flexibility used in the Papuan cultural contextual e-module is 10, the score obtained for the dialogic and interactive language aspects in the Papuan crocodile contextual e-module is 8, the score obtained for the communicative aspect is 4, the score for language suitability is 4, the score for the graphic aspect is 11, while the use of terms, symbols or icons is 7 so that the total score is 44 from a maximum score of 60. The percentage of language validity in the Papuan cultural contextual e-module is 73.33%. According to Akbar (2013:41) based on the criteria, $60{,}01\% - 80\%$it shows that the e-module is valid and can be used by making minor revisions. So, the level of validation of the Papuan cultural contextual e-module language is valid and can be used with minor revisions. In addition, the validator also provided responses and suggestions on the language of the teaching materials to improve the Papuan cultural contextual e-module material. There are suggestions and input that need to be improved; therefore, revisions are made before being tested on teachers and students. After making revisions according to the validator's suggestions and input, the Papuan cultural contextual e-module can be tested on teachers and students. The following are responses and suggestions from the validator presented in Table 6.

Table 6
Expert Feedback and Suggestions for E-Modules

No	Feedback and suggestions
1	It's okay, just adjust the colors to match best.

4) Media expert

The media expert validation test is used as an evaluator of the appropriateness of the use of media that has been developed by researchers. The data obtained are in the form of qualitative data and quantitative data. For validation data from media experts regarding the Papuan cultural contextual e-module can be seen in the appendix. The recapitulation of the research results of the Papuan cultural contextual e-module from the material aspect is presented in Table 7.

Table 7
Recapitulation of E-Module Media Expert Assessment

NO	Aspect	Total score
1	Presentation	6
2	Appearance	13
3	Compliance	12
Total score obtained		31
Maximum total score		45
Validity percentage		68.88%

Based on the presentation in Table 7, it shows that the score obtained from the assessment of the presentation of the Papuan cultural contextual e-module is 6, the score obtained for the appearance aspect of the Papuan cultural contextual e-module is 13, while the score obtained for the suitability aspect of the Papuan cultural contextual e-module is 12 so that the total score obtained is 31 out of a maximum score of 45. The percentage of media validity in the Papuan cultural contextual e-module is 68.88%, while according to Akbar (2013:41) based on $60{,}01\% - 80\%$these criteria, it shows that the e-module is valid and can be used by making minor revisions. So, the level of validation of the Papuan cultural contextual e-module language is valid and can be used by making minor revisions. In addition, the validator also provided responses and suggestions on the language of the teaching materials for the improvement of the Papuan cultural contextual e-module. There are suggestions and input that need to be improved; therefore, a revision was made before being tested on teachers and students. After revisions were made according to the validator's suggestions and input, the Papuan cultural contextual e-module can be tested on teachers and students. The following are responses and suggestions from the validators presented in Table 8.

Table 8
Media Experts' Responses and Suggestions on E-Modules

NO	Feedback and suggestions
1	In general, the contextual e-module on Papuan culture is good, equipped with fairly good video and image displays.
2	the checkered *background is a bit distracting.*
3	Distinguish between inequality of a system of two variables and inequality of two variables (check the image description on page 5 1) please check for other images!
4	Use different shading patterns or colors to make the solution areas of each given inequality more visible.

Based on the evaluation results, the percentage of material validity in the Papuan cultural contextual e-module is 77.33%. According to Akbar's assessment criteria (2013:41), if the assessment percentage is around 0.05, $60{,}01\% - 80\%$it means that the validation level of the Papuan cultural contextual e-module is valid and can be used by making minor revisions. The percentage of language validity in the Papuan cultural contextual e-module is 73.33%. According to Akbar's criteria (2013:41), this means that the level of language validation in the Papuan cultural contextual e-module is valid and can be used by making minor revisions. Meanwhile, the percentage of media validity in the Papuan cultural contextual e-module is 68.88%, which means that the level of language validation in the Papuan cultural contextual e-module is valid and can be used by making minor revisions. This opinion is in line with the results of the study by Situmorang et al. (2020) which stated that the percentage of e-module validation ranges from 60% to 80%, which indicates a fairly good level of acceptance but still requires some improvements. Therefore, this Papuan cultural contextual e-module is valid and worthy of being tested. In line with the opinion of Sohail et al. (2021) that the validation results provide valuable information for revising and improving the e-module so that it can be ensured that the module is

effective, relevant, and ready to be used in a real educational environment.

e. Practicality of contextual e-modules on Papuan culture

1) Subject teacher trial

The trial of the Papuan cultural contextual e-module practice with mathematics teachers at SMK Negeri I Agrobisnis dan Agroteknologi Nduga was conducted to obtain information about teachers' responses to the e-module. The practicality test was also conducted by two mathematics teachers. The following are the data from the practicality test results of the two teachers presented in Table 9.

Table 9
Recapitulation of Practical Assessment of E-Modules by Teachers

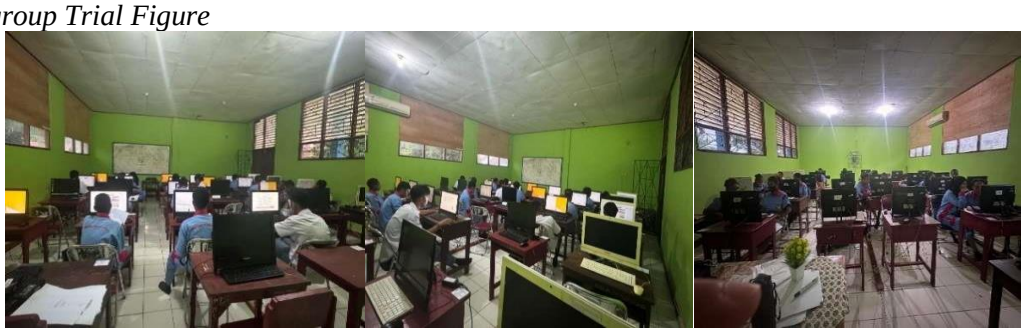
NO	Assessment aspects	Item number	Assessment score		Average
			Teacher 1	Teacher 2	
1	Effective	1	5	5	5
		2	4	5	4.5
		3	4	5	4.5
2	Interactive	4	5	4	4.5
		5	5	5	5
		6	3	5	4
		5	5	5	5
		6	3	5	5
		7	4	5	4.5
3	Efficient	8	5	5	5
		9	4	5	4.5
4	Creative	10	5	5	5
		11	4	5	4.5
		12	5	5	5
Acquisition score			53	59	56
Maximum score			60	60	60
Percentage of practicality			88.33%	98.33%	93.33%

Based on the assessment data of the two mathematics teachers in table 7, it is known that all assessment items obtained an average score of 4-5, with an average practicality percentage of 93.33%. Referring to the practicality percentage assessment table of Widoyoko (2014), a percentage value of 82%-100% was obtained which was categorized as very valid. Thus, the results of the first teacher's assessment show that the Papuan cultural contextual e-module is very practical with a practicality percentage of 88.33%. The second teacher also gave a very high assessment with a practicality percentage of 98.33% which means it is very valid (practical). However, the Papuan cultural contextual e-module has shortcomings in the interactive aspect, because one of the assessment items still obtained an average score of 4. Based on the results of the teacher's assessment, the Papuan cultural contextual e-module is very practical, effective, interactive, efficient, and creative.

2) Small-group student trials

The small group trial was conducted on June 7, 2024, in class XIa of SMK Negeri I Agribisnis dan Agroteknologi Nduga. The following is a picture of the small group trial activity presented in Figure 2.

Figure 2
Small-group Trial Figure



Small group test data were obtained from 10 grade XIa students as informants who were randomly selected from 34 grade XIa students of SMK Negeri I Agribisnis dan Agroteknologi Nduga. Small group trials were conducted in one meeting in the computer laboratory, Students shared the Papuan cultural contextual link e-module via *WhatsApp group.* Already connected to the computer server laboratory, students studied the Papuan cultural contextual e-module independently and then students were also given a questionnaire to see student responses regarding the practicality of the Papuan cultural contextual e-module.

The results of the small group trial were obtained from 10 students in class. The data from the results of the small group trial of students are presented in Table 10.

Table 10

Recapitulation of Student Assessment Results Data on E-Module Practicality

Practicality of information	Amount
Number of students	10
Highest percentage	90%
Lowest percentage	78.4%
Average percentage	85.28%

Based on the recapitulation of student assessment data in Table 8, it is known that the average assessment score for each statement item ranges from 3.9 to 4.6 with an average percentage of practicality reaching 85.28%. However, some students assess 82%, namely 78.4% and 81.6%. Based on the criteria for assessing the practicality of e-modules according to Widoyoko (2014), the assessment percentage is between 82% and 100% which indicates that the e-module is very valid.

Based on the responses of teachers and students, it can be concluded that the Papuan cultural contextual e-module is very practical to use in learning, both in face-to-face contexts and as independent learning materials. This finding is in line with the opinion of Purwoko et al. (2020) who stated that electronic modules have many advantages compared to conventional or printed modules. E-modules are more practical because they can be carried anywhere, production costs are cheaper, and the modules are also more durable (Raharjo et al., 2023). In addition, e-modules can be equipped with various multimedia elements such as audio, animation, and video that enrich the learning experience and make the material more interesting and easier to understand (El-Sabagh., 2021).

f. Effectiveness of Papuan Cultural Contextual E-modules

1) Limited field testing

A limited field trial was conducted to determine the effectiveness of the developed Papuan cultural contextual e-module. The trial was conducted in two meetings on June 10-11, 2024. Then the researcher acted as a teacher. Before learning, *a pre-test was carried out* first, to find out students' initial knowledge regarding linear program material. The *post-test* was conducted at the end of learning to measure students' understanding of the Papuan cultural contextual e-module that had been studied and students' problem-solving abilities. The implementation process of the Papuan cultural contextual e-module was carried out by the Learning Implementation Plan (RPP). The Learning Implementation Plan (RPP) was made by the researcher himself before carrying out learning activities, deep learning using the Problem-Based Learning (PBL) learning model, with question-and-answer methods, demonstrations, discussions, and assignments. And using a scientific approach. An overview of the limited field implementation activities is presented in Figure 3.

Figure 3

Limited Field Implementation Activities

2) Learning test results

The effectiveness test of the Papuan cultural contextual e-module is seen from student learning outcomes, namely students' cognitive learning achievements which are presented in Table 11.

Table 11

Recapitulation of Student Learning Outcomes

NO	Pre-exam		Post-test	
	Sign	Level of achievement	Sign	Level of achievement
1	30	KKM is not finished yet	84	Complete KKM
2	28	KKM is not finished yet	82	Complete KKM
3	33	KKM is not finished yet	78	Complete KKM
4	67	Complete KKM	100	Complete KKM
5	50	KKM is not finished yet	72	Complete KKM
6	43	KKM is not finished yet	88	Complete KKM
7	35	KKM is not finished yet	100	Complete KKM
8	42	KKM is not finished yet	86	Complete KKM
9	55	KKM is not finished yet	100	Complete KKM
10	44	KKM is not finished yet	94	Complete KKM
11	33	KKM is not finished yet	80	Complete KKM
12	40	KKM is not finished yet	80	Complete KKM
13	27	KKM is not finished yet	63	KKM is not finished yet
14	34	KKM is not finished yet	93	Complete KKM
15	10	KKM is not finished yet	76	Complete KKM
16	50	KKM is not finished yet	90	Complete KKM
17	15	KKM is not finished yet	94	Complete KKM
18	25	KKM is not finished yet	82	Complete KKM
19	30	KKM is not finished yet	68	Complete KKM
20	37	KKM is not finished yet	82	Complete KKM
21	65	Complete KKM	96	Complete KKM
22	43	KKM is not finished yet	100	Complete KKM
average score	38		85.82	
Percentage of completeness		9.09%		95.45%

Based on the learning outcomes in Table 11, the average score of students in the pretest was 38, while in the posttest it reached 85.82. According to Akbar (2013:14), if the competency test ranges from 81.00-100, then the teaching material is considered very effective. In addition, after the implementation of the Papuan cultural contextual e-module, almost all students managed to achieve the school's Minimum Completion Criteria (KKM) standard, except for one student who scored 63, which means that 95.5% of students achieved completion. This shows that the Papuan cultural contextual e-module is very effective in learning.

3) SPSS test results

The results of the effective test of the Papuan cultural contextual e-module are presented in the following SPSS output.

Table 12

Paired Sample Statistics

		Mean	N	S	Std Error Mean
Pair 1	Pretest	38,000	22	14.074663	3.00072
	Post Test	85.8182	22	10.72885	2.28740

Based on Table 12 "*Paired Samples Statistics*" it shows descriptive statistics for two conditions in a study, namely *Pre-Test* and *Post-Test.* This table contains the average value (Mean), number of participants (N), standard deviation (Std. Deviation), and standard error of the mean (Std. Error Mean) for each condition.

1) *Pre-Test*: The mean value is 38.0000 with 22 participants. The standard deviation is 14.07463, indicating how much the participants' values vary from the mean. The standard error of the mean is 3.00072, indicating the approximate level of uncertainty in estimating the population mean based on this sample.

2) *Post-Test:* The mean score is 85.8182 with the same number of participants, which is 22 people. The standard deviation is 10.72885, which is lower than the *Pre-Test score*, indicating that the post-test scores tend to be more consistent. The standard error of the mean is 2.28740.

Overall, the results show a significant increase in the mean score from *Pre-Test* to *Post-Test*, from 38.0000 to 85.8182, with a reduction in data variation as indicated by the decrease in standard deviation.

Table 13
Paired Samples Correlations

		N	Correlation	Sig
Pair 1	PreTest&PostTest	22	.478	.025

Based on Table 18 " *Paired Samples Correlations* " shows the results of the correlation between the *Pre-Test* and *Post-Test scores* of 22 participants. The correlation value of 0.478 indicates a moderate positive relationship between the *Pre-Test* and *Post-Test scores*, meaning that when the *Pre-Test score* increases, the *Post-Test score* tends to also increase, and vice versa. The decision-making above is supported by Pearson's correlation theory (Karl Pearson), which measures the linear relationship between two continuous variables, where the correlation ranges from -1 to 1, where: 1 indicates a perfect positive correlation, -1 indicates a perfect negative correlation, 0 indicates no correlation (Lanzani., 2022). The significance value (Sig.) is $0.025 > 0.05$, which indicates that this correlation is statistically significant. In other words, there is sufficient evidence to state that the relationship between the *Pre-Test* and *Post-Test scores* is not due to chance. This opinion is supported by Kafadar (2021) who stated that Ronald A. Fisher introduced the concept of statistical significance and p-value in hypothesis testing, which suggests that if the p-value is less than 0.05, the null hypothesis can be rejected and the results are considered significant.

Table 13
Paired Samples Test

		Mean	Std Deviation	Lower	Upper	1	df	Sig (2-tailed
Pair 1	Pretest-posttest	-47.81818	12.99684	2.77093	-53.58066	-17,257	21	$< .001$

Based on the " *Paired Samples Test* " shows the results of the t-test for paired data between *Pre-Test* and *Post-Test scores*. The average difference between the *Pre-Test* and *Post-Test scores* is -47.81818, indicating that the *Post-Test score* is significantly higher than the *Pre-Test score*. The standard deviation of this difference is 12.99684, and the standard error of the mean is 2.77093. The 95% confidence interval for this mean difference ranges between -53.58066 (lower limit) and -42.05571 (upper limit), which does not include zero, indicating a statistically significant difference.

The calculated t-value is -17.257 with a degree of freedom (df) of 21. The significance value (Sig. 2-tailed) $< ,001$, means that the mean difference between *the Pre-Test* and *Post-Test scores* is highly statistically significant. In other words, there is very strong evidence that the *Pre-Test* and *Post-Test scores* are significantly different, with the *Post-Test scores* being higher than the *Pre-Test scores.* Nizon *et al* (2024) stated that significance (Sig. 2-tailed): A p-value of .000 or <.001 indicates that this difference is highly statistically significant. In line with Matthews' opinion (2021) stating that if the p-value is below a certain threshold (usually 0.05), then the results are considered statistically significant, and the null hypothesis (which states there is no effect or difference) can be rejected.

Based on the description above, it can be concluded that the Papuan cultural contextual e-module has proven to be very effective in improving student learning outcomes, especially in improving students' abilities to solve mathematical problems, especially story problems. The integration of Papuan culture in the e-module not only enriches the learning context but also makes it more relevant and meaningful for students, which has a positive impact on the understanding and application of mathematical concepts. This finding is in line with the research of Sriyanti et al. (2022) which emphasized that the e-module is a practical and effective tool in the learning process. The results of the study showed that the e-module not only facilitated better understanding of the material but also increased student engagement in learning. Thus, the Papuan cultural contextual e-module not only functions as an innovative educational tool but also as a bridge between academic knowledge and local cultural richness, thus having a significant impact on student learning outcomes.

After going through a series of stages in the development of Papuan cultural contextual e-modules, a Papuan cultural contextual e-module was successfully produced with valid, practical and effective quality in improving student learning outcomes, especially in mathematical problem-solving abilities. This opinion is supported by the results of Wishar et al (2023) which show that e-modules in student learning are proven to be valid, practical and effective. Research by Raharjo et al (2023) also shows that valid, practical and effective e-modules can significantly improve students' mathematical problem-solving abilities. The validity of the e-module is seen from the suitability and accuracy of the content, to ensure that the material presented is in accordance with the curriculum and is easy for students to understand (Situmorang et al., 2020). The practicality of the e-module is reflected in its ease of use in various learning situations, both in terms of face-to-face and independent learning, as well as its flexibility that allows students to access materials anytime and anywhere (Bhat et al., 2022). The effectiveness of the e-module is seen from the increase in student learning outcomes, where students show better abilities in solving mathematical problems after using the e-module (Islahiyah et al., 2021). The integration of multimedia elements such as videos, animations and interactive quizzes in e-modules also contributes to increasing student engagement and motivation, so that they are more interested and active in learning complex mathematical concepts (Handog et al., 2024).

This e-module not only plays a role in improving students' understanding of mathematical concepts, but also integrates and interprets Papuan culture in general in depth in linear programming materials. With a contextual and local culture-based approach, this e-module makes learning more relevant and meaningful for Papuan students, enriches their learning experiences, and strengthens the relationship between culture and science. This is by the view of Tafazoli (2024), who emphasized that cultural contextual e-modules can bridge culture and formal education, making learning more holistic and rooted in the local context. In addition, cultural contextual e-modules also encourage students to see mathematics not only as a collection of numbers and formulas but as a tool to understand and appreciate their own cultural heritage (Ying Lo., 2023). Through the integration of cultural elements into mathematics materials, e-modules play a role in building students' cultural identity while developing their academic skills, and creating a positive synergy between education and local culture (Latif et al., 2021).

4. Conclusion

The results of the implementation of the Papuan cultural contextual e-module show that this e-module is valid and practical. Validation from material, language, and media experts showed validity of 77.33%, 73.33%, and 68.88%, respectively. The assessment of two mathematics teachers and 10 students of SMK Negeri I Agrobisnis dan Agroteknologi Nduga gave an average practicality score of 93.33% from teachers and 85.28% from students, indicating that this e-module is interactive, efficient, and creative. The teacher's response was very positive, with 68% strongly agreeing and 32% agreeing that the e-module is relevant to the curriculum and easy to use. Students also gave positive assessments, with 42% strongly agreeing and 53% agreeing, indicating that this e-module is interesting, effective, and relevant to Papuan culture. Its effectiveness is proven by the results of the PreTest and PostTest which show a significant difference with a significance (Sig. 2-tailed) $<$ of 0.001, as well as the achievement level of the Minimum Completion Criteria (KKM) of 95.5%, confirming that this e-module is very effective in improving students' mathematical problem-solving abilities.

The Papuan cultural contextual e-module produced in this study can be an effective additional teaching material for teachers and students in facilitating the mathematics learning process and independent learning in improving students' mathematical problem-solving abilities, especially in the linear program material for grade XI SMK. In addition, this e-module is expected to be an example and source of motivation for teachers to develop more varied, innovative teaching materials that utilize technology also the Papuan cultural contextual e-module functions as a tool to preserve and appreciate Papuan culture while strengthening students' identity and pride as part of Papuan culture.

Limitations

The limitations of this study include the small sample size, involving only two teachers and 10 students from SMK Negeri I Agrobisnis dan Agroteknologi Nduga, which may limit the generalizability of the results to other schools with different contexts. Additionally, the study focuses solely on linear programming material, so the effectiveness of the e-module has not been tested on other topics.

Validation was carried out by a limited number of experts, and the duration of e-module implementation was not detailed, making it difficult to assess its long-term impact on students' learning outcomes.

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Author Contribution
Karunia Tumba Sanda Pakabua: Conceptualization, Writing - Original Draft
Sudirman : Review & Editing
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Camilo Andrés Rodríguez-Nieto: Validation and Supervision.
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Conflict of Interest
The authors declare no conflict of interest.

Additional Information:
Additional information is available for this paper.

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