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Research Article

Constructing critical thinking module to teach math logic for vocational school student

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Abstract

Critical and logical thinkers are in high demand in the workforce. Vocational students need to possess this knowledge if they plan to work after graduation. Nevertheless, there aren't many Math Logic modules designed for students in vocational schools that have this ability. The goal of this research is to provide module that facilitating students at vocational schools to improve their critical thinking abilities. Utilizing 4-D Thiagarajan steps, this study using R&D method. Critical thinking ability tests, teacher and student answer questionnaires, and expert validation sheets are the instruments employed. Both quantitative and qualitative analysis was done on the data collected from the instruments. The data processing results demonstrate: 1) valid modules, as determined by validity test results from media, practitioners, and subject matter experts; 2) high-quality modules, as determined by student and teacher response results; and 3) useful modules, as determined by effectiveness test results in the classroom. The module can be utilized for instruction at vocational schools.

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Introduction

Students who study in vocational schools concentrated on skills that will be necessary in the labor market. One of those is critical thinking skill (Changwong et al., 2018). Mastering this skill is necessary to enable someone to understand, assess, evaluate, make judgments, and provide context for evidence (Selviana et al., 2016). This skill also related to student's career preparation (Baidowi et al., 2021).

Despite the necessity to think critically, multiple studies have found that vocational school students' critical thinking abilities remain low. At global scope, study from Deechai (2019) reported that Thai student still had low critical thinking skill degree. Meanwhile national studies found that vocational school learners in Boyolali saw low category in this skill (Ari et al., 2018). In line with this study, another research also revealed that the skill to think critically of students in one Semarang school remained low (Lestari et al., 2020). Meanwhile, Mataram's vocational school students who are predicted to be able to work after graduating also experienced low at this skill (Baidowi et al., 2021).

Critical thinking abilities will be taught in vocational school through instructional activities. These exercises include both theoretical and practical components (Eryandi & Nuryanto, 2020). Logic is one of the topics covered in

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vocational school mathematics classes. This content teaches learners how to develop logical conclusions . In everyday life, it is necessary to draw logical conclusions. This ability is essential to optimizing critical thinking abilities because being able to make logical conclusions is one indicator of critical thinking ability (Ennis, 1985).

Several studies have indicated that the outcomes of learning for vocational school students in Logic material are still low. Sawitri's research found that student at one of Cimahi's vocational schools still did not understand Logic content adequately (Sawitri, 2020). In two of the three measures examined, these students were classified as poor or extremely poor. Teachers have trouble expressing logical concepts to students, making logic material challenging (Septiani et al., 2022). Students struggle to determine the equivalence of compound sentences, the conclusion from two premises, and the truth value of compound phrases (Mirati, 2015).

Teachers can integrate classroom mathematics questions with mathematics in everyday life to enable learning that is relevant to the workplace (Baidowi et al., 2023). Teaching learning based on real-life circumstances, according to Magwilang, is helpful in enhancing students' enthusiasm to study (Magwilang, 2016). Aside from that, contextual learning is able to facilitate students to improve their logical reasoning skills (Septiani et al., 2022)

Several previous studies investigated the development of textbooks for vocational school mathematics lessons aimed at improving critical thinking skills. STEM-based mathematics materials on arithmetic sequences and series have been developed by (Insani et al., 2021). Pertiwi et al. have also created specific teaching materials based on Matrix content (Pertiwi et al., 2021). However, limited researches have been conducted to generate module on math logic.

Reflecting the solutions provided and ongoing research, this study aims to developing a math module based on Logic for vocational school math teachers. This study will focus on the development of educational materials using the Merdeka curriculum as the new curriculum in Indonesia.

Method

Research Model

This study was categorized as development research using the model of 4-D, namely define, design, development, dissemination (Thiagarajan et al., 1974). The 4-D research steps were presented in Figure 1.

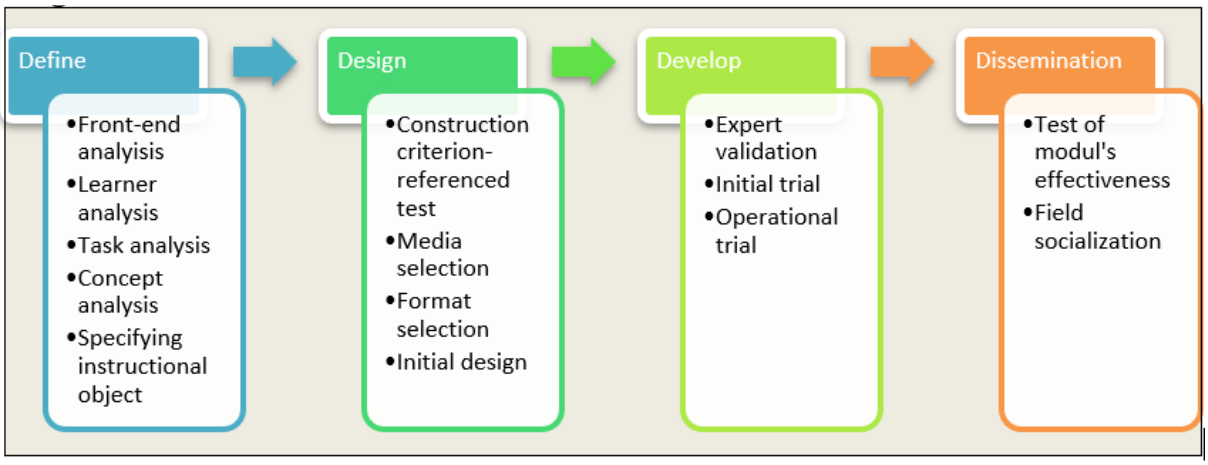

Figure 1. The Flowchart of The Research

Participants, Sampling and Data Analysis

Researchers analyzed the module's needs during the define stage by interviewing teachers at the school where the module would be tested, namely teacher of eleventh grade SMKN 4 Mataram, Indonesia, examining respondents who would use teaching materials, organizing the topic for discussion, and refining learning objectives into more practical goals.

During the design phase, researchers developed reference tests to evaluate the module's efficacy, selected the module delivery medium, decide on the ideal module format, and design the module. Expert validation is then conducted at the develop stage using practitioners, media experts, and material experts. Teachers at SMKN 4 Mataram, Indonesia, who

will be using the module as a teaching tool were the practitioners, and math education lecturers serve as the media and material specialists.

The data obtained from expert validation was then added up and then averaged. Then, the average score was converted into categories as in Table 1 (Ratumanan & Laurens, 2016). The module can proceed to the dissemination stage if the module is at least in a valid category

Table 1. The validity of module

Interval's score	Category	Information
$\mathbf{1 \leq P \leq 1.75}$	Very invalid	Can not be use
$\mathbf{1,75 \leq P \leq 2.75}$	Invalid	Can be used but many revisions required
$\mathbf{2.75 \leq P \leq 3.25}$	Valid	Can be used but with several revisions
$\mathbf{3.25 \leq P \leq 4.0}$	Very valid	Can be used with minor revisions

Note: P= the score's average from all validators

Furthermore, in the dissemination stage, the researcher experimented the module to two culinary art class at eleventh grade with total 64 students and gave the questionnaire to collect the respond of students and teacher who already studied using the certain module. Researchers compared the use of the module in classes that studied using school textbooks alone with classes that studied using school textbooks and modules in order to assess the efficiency of using the module during the dissemination stage. The T test was then applied to the given data. The degree to which the class studied using school textbooks and module outperforms the class which just studied using school textbooks was what determines the effectiveness of the module. Otherwise, fixes for problems that could improve the functionality of the module will be made. Meanwhile, the data obtained from the questionnaire given to students and lecturers was analyzed using the classification in Table 2 (Widoyoko, 2016).

Table 2. The formula to classify module's category

Formula	Classification
$\boldsymbol{X > \bar{X}_i + 1,8 \times sb_i \Leftrightarrow X > 27,2}$	Very good
$\boldsymbol{\bar{X}_i + 0,6 \times sb_i < X \leq \bar{X}_i + 1,8 \times sb_i \Leftrightarrow 22,4 < X \leq 27,2}$	Good
$\boldsymbol{\bar{X}_i - 0,6 \times sb_i < X \leq \bar{X}_i + 0,6 \times sb_i \Leftrightarrow 17,6 < X \leq 22,4}$	Enough
$\boldsymbol{\bar{X}_i - 1,8 \times sb_i < X \leq \bar{X}_i - 0,6 \times sb_i \Leftrightarrow 12,8 < X \leq 17,6}$	Not good
$\boldsymbol{X \leq \bar{X}_i - 1,8 \times sb_i \Leftrightarrow X \leq 12,8}$	Very bad

Note:
$\bar{X}_i = {}^1/_2$ (maximal ideal score + minimal ideal score) = ½ × (32 + 8) = 20
$sb_i = {}^1/_6$ (maximal ideal score - minimal ideal score) = $\frac{1}{6} \times (32 - 8) = 4$
X = the sum of the score

After revised the module according to teacher and students feedback, the module could be disseminated more. Supplementary dissemination of the module can also be achieved by distributing it to classrooms in the same school.

Data collection and application

At define stage, the data was collected using interview guidelines and literature study. Meanwhile, at development stage, the data collected from instruments, such as validator form for material expert, media expert and practitioner, and student form response. Finally, in the dissemination stage, we utilized the data for critical thinking skill of students using critical thinking test in logic math topic in the form of essay and collected student and teacher response using. We also used the questionnaires to collected the feedbacks from teacher and students who already studied using this module.

Results

The study's findings are categorized as follows: definition, design, development, and dissemination.

Define Stage

This phase attempts to determine the issues and specify requirements for module development. The Logic content for SMKN 4 Mataram class XI students will be turned into a module. This study employed observation, documentation,

and interview data collecting procedures as data collection methods. The define stage comprises five primary steps, which are front-end analysis, analysis of learner, and task analysis (Asriani et al., 2017).

To illustrate the reasons behind module development, a front-end analysis is carried out. The study involved two main methods: first, a review of the teaching materials for the class XI Logic material for the Independent Curriculum which was published by the Education and Culture Ministry at the Vocational School level; second, an interview with math teachers at SMKN 4 Mataram City regarding the significance of combining critical thinking modules for class modules used during learning. According to interviews with school mathematics teachers, teachers have not taught utilizing modules that help build students' critical thinking skills, particularly in Logic subject. The book that has been used thus far is a ministry package book. Teachers require a module that includes detailed phases of learning that can be developed.

Student analysis is a stage for identifying student characteristics where field trials are used. Trials will be held in class XI for students majoring in Culinary Art I and Culinary Art II. There are 35 students in the Culinary Art I class, and 31 male and female students in the Culinary Art II program. Students in both courses preferred practical instruction over studying primarily through books and written questions, based on teacher assessments.

Determining the main skills that students have learned is the aim of task analysis. Fundamental competencies and particular learning objectives are selected at this level. One of the specific goals to be achieved in the educational materials provided is to increase students' abilities on thinking critially. Following that, concept analysis is done to determine the concept and learning processes taken. The content used is logic material about statements, negation, conjunctions, disjunctions, implications, biimplications, and forming conclusions. The program includes steps for problem-based learning together with logical content. Furthermore, specific learning objectives to be attained are specified by putting critical thinking ability indicators in each learning objective. Students will be able to identify the material relevance when solving contextual problems employing implication and biimplication rules, according to the learning objectives outlined.

Design Stage

The initial phases of product design are included in the design stage. Preparing benchmark testing, selecting media, selecting the module format, and basic design are the steps at this point. The design stage includes initial efforts at product design. At this point, preparations are made for benchmark testing, media and format selection, and basic design. The creation of benchmark exams is based on the required learning outcomes. The instructional tools used to evaluate students' critical thinking skills convert the benchmark exam into a knowledge test. In the media selection process, we choosed the paper based module because both the field trials's subject told interviewers that they perceived easier using paper based module than they did with alternative media like electronic media. Concurrently, the teaching materials have been developed in a module style that aligns with the Merdeka Curriculum. Subsequently, a preliminary design for the module under development is produced.

Figure 2 depicts the original module design that was in use. According to Figure 1, the module's original design included a number of articles and genuine data that served as the basis problem for learning. For example, in the material regarding drawing conclusions, the question taken is the issue of developing white bread dough which is related to the culinary arts department. The question uses a sentence excerpt, namely if the room temperature is too cold, then the dough will not rise perfectly. For example, if the dough does not rise perfectly, can it be concluded that the temperature around the bread is too cold? This problem directs students to draw conclusions using various existing methods.

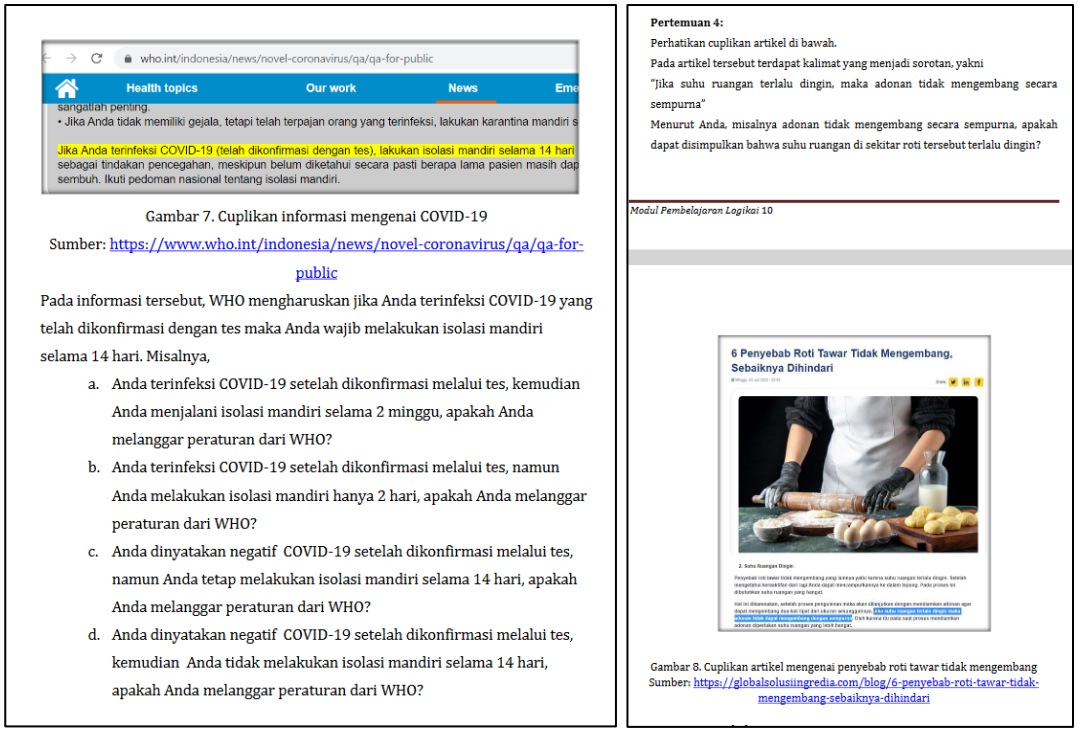

Figure 2. Initial design of module

Develop Stage

The development stage includes validation by specialist, operational trials, early testing, and product revisions. Specialist validation is carried out by an expert in material, an expert in media (module), and an expert from practitioner view. In contrast to module media expert validity, which evaluates the appearance, language, completeness, and suitability of the module's sequences, material expert validation evaluates the accuracy and suitability of the material presented for learning objectives. Practitioner validation will be carried out by the math teacher at SMKN 4 Mataram, who will serve as the module's pilot. This validation's objective is to evaluate the module's value for educational activities. The following Table 3 provides the validation results from the three specialist.

Table 3. The validation's result from validators

Specialist in Content		**Specialist in Media**		**Specialist from Practitioner View**	
Factor of Eligibility	Average Score	Factor	Average score	Factor of Eligibility	Average score
Content	4	Module size	4	Content	4
Presentation	4	Modul-cover design	3,5	Presentation	4
Language	3,5	Module-content design	3,5	Language	3,5
Content contextuality	4				
The score's average for each expert	3,88		3,67		3,83
The score's average of all validators			3,79		

Table 3 shows that the three validators have an average score of 3,79. Table 1 indicates that this score falls into the "very valid" category. It indicates that, with little changes, the module is usable. Moreover, Table 4 presents the recommendations made by the three validators.

Table 4. The Recommendations from Validators

Specialist in Material	Specialist in Media	Practitioner
• **The language in the practice questions about creating questions needs to be clarified.**	• Modules can be equipped with mind maps to help for students to understand the entire contents of the module	The problem in negation needed to be updated to the problem related to student

The validator's recommendations were incorporated into the modified module. Revisions include changing the wording of the exercise problem. One of the modules developed in response to that recommendation was shown in Figure 3. The first trial then made use of the updated module.

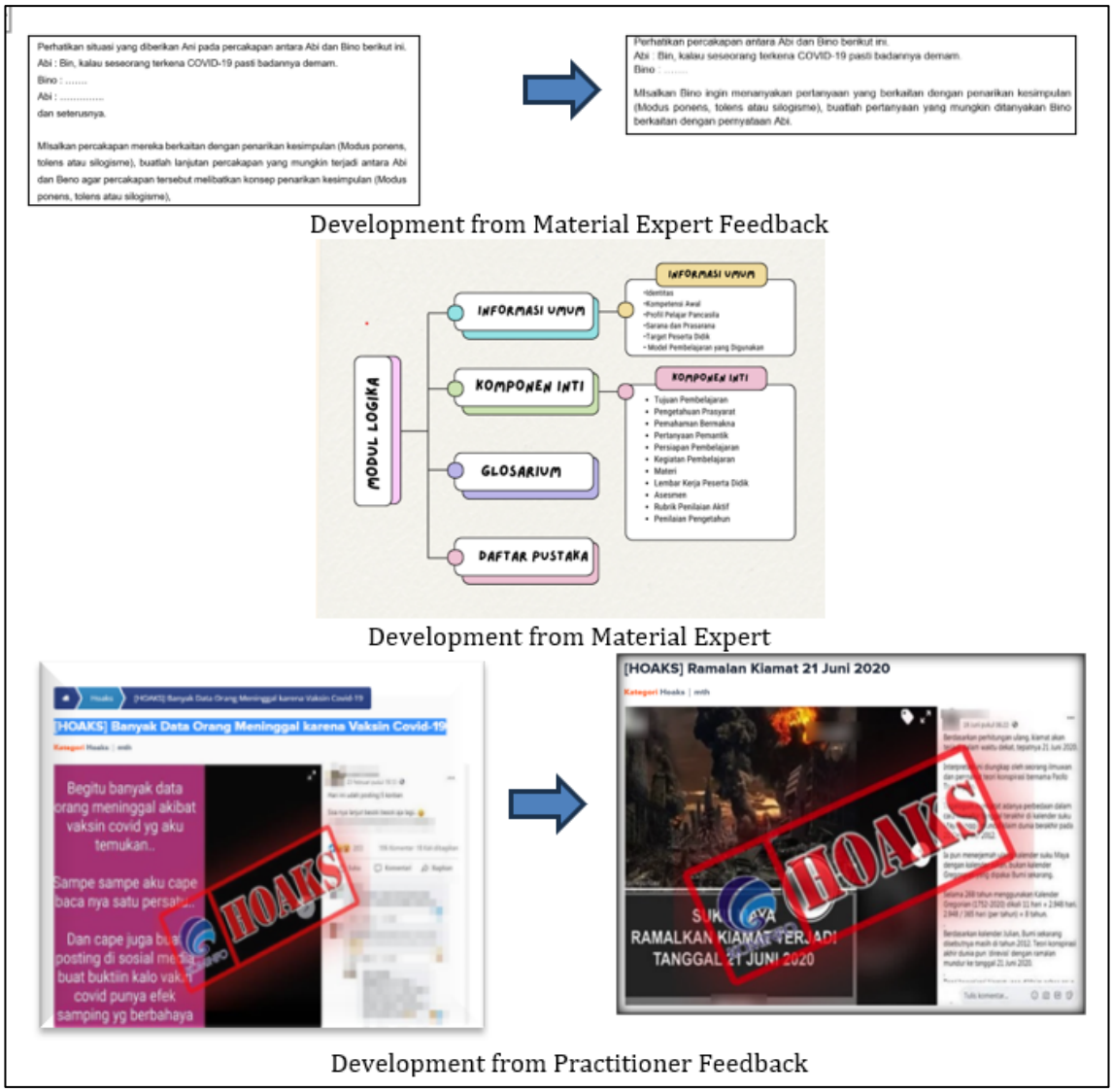

Figure 3. The modification of module from validator's suggestion

Field trials were conducted at SMKN 3 Mataram's Class XI Culinary Art class. Following that, teachers and students complete a questionnaire to provide feedback on areas of the module that may be improved. The average score from student feedbacks was 2,89. This indicates that the module is rated as good in Table 2. Meanwhile, 3.75 is the average score for teachers. According to Table 2, teacher classified this module as a very good module. As the responses from both teachers and students indicate that the module is excellent, it is prepared for dissemination stage.

Dissemination Stage

The disseminating stage involves final product improvement, outreach to the field, and actions to assess textbook effectiveness based on student results. The efficacy test was conducted at SMKN 3 Mataram using experiments. Class

XI Culinary Art I is an experimental class that uses textbooks and modules, while class XI Culinary Art II is a classroom setting. The comprehension test in the module was used to assess each class's critical thinking skills after they had studied in accordance with the experimental criteria. To analyze the result, the T-test was then used .

The following are specifics regarding the test's effectiveness result in both of the XI classes at SMKN 4 Mataram. First, tests of homogeneity and normality were run on the critical thinking skills data from both classes. Table 3, Table 4, and Table 5 present the findings.

Table 3. The Experiment Test Result's

	Shapiro-Wilk		
	Statistic	df	Sig.
Culinary Art I	.943	31	.100
Culinary Art II	.937	31	.070

The sig. values obtained are 0.100 and 0.070 based on Table 3 for Culinary Art I and II, respectively. Significance = 0.05 for both. Since sig values > 0.05, it indicated that critical thinking skills data in Culinary Art I and II were from a population that was normally distributed. Likewise, the independent T-test can be performed because both sets of data have a normal distribution.

The T test was conducted with the following assumptions: H_0 = the the were equivalent to those of the Culinary II class, and H_1 = the Culinary I class critical thinking skills outperformed the Culinary II class with $\alpha = 0.025$ is the significance chosen. Table 4 displays the outcomes of the independent T test.

Table 4. The independent t-test's result

		t	**df**	**Sig. (2-tailed)**
Culinary Art I_Culinary Art II	Equal variances assumed	3.922	64	.000
	Equal variances not assumed	3.858	55.832	.000

The sig (2-tailed) in Table 4 is 0.000. Given that the test is one-tailed and is based on the hypothesis, 0.000/2 = 0.0005 is the significance value that was employed. The significance value of 0.025 is exceeded by this sign. This indicates that H0 is rejected, which suggests that the Culinary Art Class I students have greater critical thinking skills than the Culinary Art Class II students. Thus, the module's effectiveness in enhancing students' critical thinking abilities may be concluded.

Discussion

The result showed that the module met the validity and effectiveness criteria. It implies that the module is able to be utilized by teacher in their lesson to enhance student critical thinking skill. The module featured the question related to student daily activities. This contextual condition helps student to enhance their critical thinking (Lestari et al., 2021; Toheri et al., 2020). Hence, the feedbacks from the practitioner to adjust the question about negation into the more contextual one could be one of the main factors to elevate the quality of this module.

Despite the validity of the module categorized as very good, there are still another aspect to revised from the module, such as the clarity of the language. The language aspect experiences the lowest score among other aspects at this module validity test. Language can become barrier to do evaluating as the factor of thinking critically. As Manalo and Sheppard (2016) state that the clarity of the instruction language in the question help student to demonstrate their critical thinking in their written work. The revision of the instruction language in the question could be one of the aspects to supports this module effectiveness.

The instructional materials, such as modules, are one of the aspects that affect how well students learn (Megayanti et al., 2020). The effectivenes of the modules studied in this study prove that statement. Modules become an creative method of instruction that can support students' success and produce superior results (Logan et al., 2021). Certain

learning model which utilized module as their primary tools can enhance student outcomes like critical thinking (Hikayat et al., 2020; Retnowati et al., 2020).

After the module's effectiveness has been determined, the dissemination of this module was done thorough service activities with the community of math teachers at vocational schools around Mataram City, Indonesia. This activity enabling math teachers from other vocational schools in the city to utilize this module in their lessons.

Conclusion

The result analysis revealed that the mathematics module for the 11th grade of vocational school majoring in Culinary Art in Logic material satisfied the requirements for use in learning after it was evaluated by practitioners, media specialist, material specialist, students and teacher.

Recommendations

In this research, the module was construct based on culinary art student activity. The module can be changed by the teacher based on the environment and student conditions hence the question still contextual to student daily life. This also can be the next area of research to adjust the question about math logic according to student major in their vocational school.

Limitations of Study

This study was only done in culinary art student at SMKN 4 Mataram, Indonesia. Further dissemination at culinary art student in another province in Indonesia should be done to improve the effectiveness of this module.

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