Development of Case Based Food Microbiology Textbooks to Improve Critical Thinking Skills

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Abstract. This study aims to determine the feasibility of developing case-based food microbiology textbooks based on assessments from subject matter, educational technology, and language experts. Knowing the response of lecturers and students and knowing the effectiveness of textbooks in terms of critical thinking skills. Materials and Methods: Textbook development using the ADDIE design model. The population in this study were all fifth semester students of the Biology Study Program, Universitas Negeri Medan. The sample for this study was 50 students. Data collection instruments used werre questionnaires, test and interviews. Data analysis techniques use quantitative and qualitative data. Qualitative data were obtained from the results of the needs questionnaire, while quantitative data were obtained from textbook feasibility assessment scores given by material, learning technology, and language experts, responses from lecturers and students, as well as product effectiveness test results. The results showed that the material validation experts were in the feasible criteria (91%), the linguists validation was in the very feasible criteria (88%) and learning technology experts validation was in the very feasible criteria (83%). The results of the lecturers responses were in very good criteria (84%) and the results of student responses were in very good criteria (88%). The t-test results obtained in the experimental and control classes were 0.000 (2-tailed) <0.05 so it can be concluded that there is a significant difference. This shows that there is a significant effect on the treatment given before the pretest and after the posttest. The average N-gain value obtained in the experimental class given food microbiology textbooks was 62.56 which was included in the moderately effective category. Meanwhile, the average N-gain score for the control class without being given a food microbiology textbook was 42.28, which was included in the less effective category. Based on the N-gain test, it can be interpreted that the use of case-based food microbiology textbooks has a fairly good level of effectiveness in increasing critical thinking skills. The research that has been carried out produces a case-based food microbiology textbook to improve critical thinking skills with very good criteria from validataor materials, learning technology validators, language validators, lecturer responses and has gone through a private, small and large trial process. So that it is limited according to the material nedds and characteristics of student.

Keywords: Textbook Development, Food Microbiology, Critical Thinking Skills.

1 Introduction

Regulation of the Minister of National Education of Indonesia Number 11 of 2005 Article 2 types of textbooks as follows: (1) Textbooks used as mandatory references by teachers and students in the learning process; and (2) enrichment books and reference books which function to increase students' knowledge and insight. Textbooks have two main missions, namely: (1) Textbooks must be good sources of knowledge and media and can enhance the learning process; and (2) textbooks are expected to help the learning process in order to increase students' knowledge. In Regulation of the Minister of Education and Culture No. 754 of 2020 concerning Main Performance Indicators for State Universities, namely case studies used as learning material for solving case studies in national tertiary courses. At the higher education level, the learning process is directed at the learning outcomes of subjects in the form of competencies that have been formulated in the Indonesian National Qualifications Framework (KKNI), which include critical thinking competencies and problem-solving skill competencies.

Food Microbiology is a compulsory subject in the Unimed Biology Study Program. Food microbiology is the science that studies the effect of processing on microorganism cells, including the mechanisms of resistance of microorganisms to processing. Besides that, it also studies harmful changes such as spoilage and food poisoning, as well as beneficial changes such as in food fermentation. The process of processing and preserving food cannot completely prevent all adverse changes.

In the 21st century skills require not only cognitive aspects but also affective and psychomotor aspects. Therefore, in the 21st century education students are required to be able to think logically, think critically and creatively, and have the ability to solve problems. In line with the integration of the student assessment process which can describe higher order thinking skills[1]. Students' critical thinking skills expressed through tests of students' critical thinking skills as a whole are in the indicator range of 2.92 with criteria not yet visible or still underdeveloped. To become a critical thinker requires awareness and skills to maximize brain work through good critical thinking steps, so that the framework and way of thinking are arranged in a good pattern[2].

Learning by analyzing cases that occur around it, will stimulate students to find out answers to these cases and in the end be able to improve students' critical thinking skills in the form of increasing from understanding to application, synthesis and analysis and making it an independent learning. The use of case-based textbooks (case method) in the learning process will provide opportunities for students to analyze problems presented in the form of cases, make conclusions based on available information, to draw conclusions about the assumptions that have been formulated[3]. Previous research has found that case-based learning is better than conventional methods, where case-based learning can improve critical thinking skills and class interaction[4].

2 Method

This research will be conducted at Medan State University which is located at Jl. William Iskandar Medan Estate to fifth semester Biology Study Program students. This research was carried out starting from the preparation stage to the implementation stage, namely designing

and developing teaching materials starting in August-October 2022. Textbook validation was carried out in November-December 2022. Test the effectiveness of textbooks in January 2023. The population in this study were all students of Study Program Medan State University Biology which consists of 4 classes with a total of 101 students. The sample used in this study was 50 students from PSB A and PSB B classes.

The type of research used is Research & Development with the ADDIE model. The ADDIE development model consists of several stages, namely analysis, design, development, implementation and evaluation[5]. The development of this product was validated by material validators, learning technology and language validators and was tested on individual groups of 3 people, small groups of 9 people and a limited group of 21 biology study program students at Medan State University who had taken food microbiology courses.

Data collection was carried out by distributing questionnaires as well as pre-test and post-test questions. The research instruments consisted of tests and non-tests. The test given consists of multiple choice questions given to students to see an increase in critical thinking skills. While the non-test consists of a preliminary study questionnaire, material validation questionnaire, learning technology validation questionnaire, language questionnaire and lecturer and student response questionnaires.

The data analysis technique used is qualitative and quantitative analysis. Comments and input from validators, lecturers and students are qualitative data. While the analysis of quantitative data from test results, validation questionnaires and the responses of lecturers and students. Data analysis was performed based on the Likert scale. According to Sugiyono the Likert scale is used to measure a person's attitudes, opinions and responses. The validation data is in the form of values 1-5 which are analyzed according to the criteria based on[6] with alternative answers, namely: very good (5 score), good (4 score), quite good (3 score), not good (score 2), not very good (weight value 1). The level of validity of the validation is done by calculating the percentage of each indicator using the following formula:

$$\text{Validity} = \frac{\text{Total score obtained}}{\text{Total maximum score}} \, x \, 100\%$$

The validity test was carried out, namely material, learning technology and language. Assessment of validity is presented in **Table 1**:

Table 1. Product Feasibility Scale

Presentation Score (%)	Category
$81.25 < \text{score} \leq 100$	Very Worth it
$62.5 < \text{score} \leq 81.25$	Worthy
$43.75 < \text{score} \leq 62.5$	Less Eligible
$25 < \text{score} \leq 43.75$	Not feasible

Quantitative analysis of the test items was calculated using SPSS version 22 software by comparing the scores obtained from the pre-test and post-test. The test questions provided included indicators of critical thinking skills and problem solving. Data analysis was performed by t test with Sample t-Test. To find out the increase in students' critical thinking skills before and after using textbooks using the N-Gain formula as follows:

$$(g) = \frac{T2 - T1}{Sm - T1}$$

Information:
g = Normalized gain
T1 = Pretest score
T2 = Posttest score
Sm = Maximum score
The amount of normalized gain is determined by the criteria as in **Table 2.**

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Table 2. Normalized Gain Ranges

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Normalized Gain Range	Effectiveness Criteria
< 40	Ineffective
$40 - 55$	Less Effective
$56 - 75$	Effective Enough
> 76	Effective

The research was carried out starting with the analysis phase consisting of needs analysis and material analysis which aims to determine student needs in the implementation of learning. Then a textbook design was carried out which was carried out by collecting information and sources related to the material, namely food microbiology material. Next, design a food microbiology textbook. After the product has been made, it is continued with the development stage through the material validation process, language validation and learning technology validation. as well as product trials for students which are divided into individual groups, small groups and limited groups. Textbooks that have been appropriate and good from the results of validation and trials are implemented for students. Implementation aims to determine the increase in students' critical thinking skills using the Nonequivalent Control Group Design. This design uses two classes, each of which is given a pretest-posttest. The results of the test are then carried out by the N-gain test. Then, at the end, a formative and summative evaluation is carried out so that the textbook is good for use in learning food microbiology.

3 Result And Discussion

3.1 Results

The results of the development research conducted were case-based textbooks on microbiology material to improve students' critical thinking skills. This development is carried out through 5 ADDIE stages, namely analysis, design, development, implementation and evaluation.

1. Analysis phase
Curriculum analysis was carried out by examining the curriculum used, namely the curriculum based on the Indonesian National Qualifications Framework integrated with the curriculum for independent learning and an independent campus which is ongoing at the Biology Study Program, FMIPA, Medan State University. The results of the analysis of Semester Lecture Plans show that one of the basic competencies that must be achieved is that students are able to explain Food Microbiology. So far, the learning process is carried out through lectures, discussions, presentations. The references that have been used so far only explain the basic concepts, there has been no renewal of references considering that there are more and more easy access to find supporting or updated references. The results of the questionnaire that has

been carried out show that as many as 94% of students say they have difficulty understanding learning Food Microbiology material. As many as 71% of students said that the current textbooks used were minimal about cases. As many as 100% of students wanted to have a case-based book on Food Microbiology material and 100% of students said that having a case-based book could stimulate them to have the ability to think and solve problems. From these results it can be concluded that case-based Food Microbiology teaching materials are urgently needed by students in order to stimulate critical thinking skills and problem solving.

2. Design (Design)

At this stage do it to design a case-based Food Microbiology textbook to train critical thinking skills and problem solving for Biology Study Program students at Medan State University which can be used as learning resources for students as shown in **Table 3**.

Table 3. Design of food microbiology textbooks

Section	Component
Introduction	Front cover
	Foreword
	List of contents
Contents	Learning objectives
	Learning title
	Food microbiology material
	Images related to food microbiology material
	Summary
	Case study
	Pertanyaan
Closing	Bibliography
	Glossary
	Back cover

3. Development Stage

Textbooks were developed to contain food microbiology material for biology students. The paper size used is A4. The number of pages of the developed textbook is 162 pages seen in **Figure 1**.
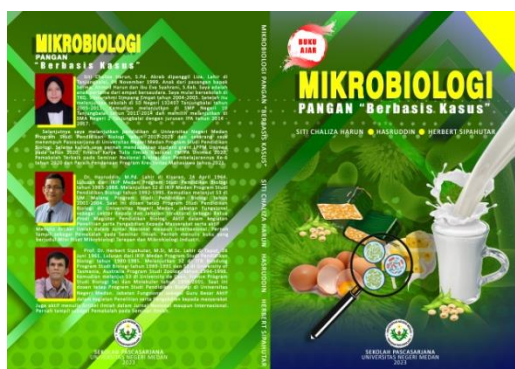

Figure 1. Front and back covers of textbooks

Figure 1 is the result of a food microbiology design that has been revised from the results of the material validator, language validator and learning technology validator. The use of letters is clearer and the background color is opposite to the text used. The cover image presented

relates to the material discussed in the textbook. Suggestions from the results of material validation can be seen in **Table 4** below.

Table 4. Results of the Validation of the Textbook Material Expert Team

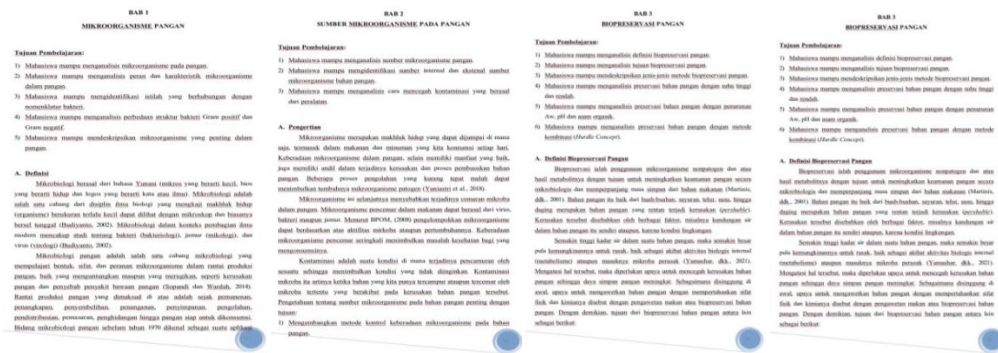| Evaluation	Respondents	
	1	2
Material Coverage	75%	100%
Material Accuracy	88%	100%
Update	92%	75%
Contains Productivity Insights	88%	100%
Stimulate Curiosity	88%	100%
Develop Life Skills	92%	100%
Total Percentage	**88%**	**95%**
Category	**Very Worth it**	

Figure 2. Display of Case-Based Food Microbiology Textbook Contents

Table 4 is the result of material validation that has been carried out. From the results of the validation process the average results obtained were 88% including the very feasible category, 95% including the very feasible category. The results of this validation continued to increase so that it was found that case-based food microbiology textbooks were tested on students. The validation results from learning technology experts can be seen in **Table 5** below.

Table 5. Textbook Learning Technology Validation Results

Evaluation	Respondents	
	1	2
Serving Technique	88%	75%
Presentation of Learning	100%	75%
Presentation Completeness	79%	86%
Total Percentage	**85%**	**81%**
Category	**Very Worth it**	

Table 5 is the result of the learning technology validation that has been carried out with an average score obtained in validator 1 of 85% and validator 2 of 81% including the very feasible category. The validation results from linguists can be seen in **Table 6** below.

Table 6. Textbook Language Validation Results

Evaluation	Respondents	
	1	2
Straightforward	100%	83%
Communicativeness	75%	88%
Consistency and Congruence of Thought	88%	88%
Total Percentage	**89%**	**86%**
Category	**Very Worth it**	

Table 6 is the result of language validation that has been carried out with an average score obtained in validator 1 of 89% and validator 2 of 86% including the very decent category. Suggestions and input from the validator can be presented in **Table 7** below:

Table 7. Validator's Suggestions and Follow-up on Textbooks

Validators	Suggestion	Information
Material	• Needs to be updated • The words used must be consistent • Simplify the sentences used to make it easier to understand	Fixed
Learning Technologies	• Image captions must be consistent • Chapters I and II must be added with pictures • Add concept maps for each chapter • Better morphology first then characteristics and roles	Fixed
Language	• Improve sentence structure • Make sentences effective • Use standard language • Pay attention to grammar • Align paragraphs • Eliminate references that use blocks with unclear sources	Fixed

Textbooks that have been validated by material validators, learning technology and language after revision are subject to textbook assessment by food microbiology lecturers. The results and suggestions can be presented in **Table 8** below.

Table 8. Assessment of Textbooks by Food Microbiology Lecturers

Evaluation	Respondents	
	1	2
Material Suitability	75%	81%
Presentation	85%	90%
Effectiveness	81%	88%
Total Percentage	**81%**	**87%**
Category	**Very Good**	

The average of the results of the assessment of lecturer 1, namely 81%, is included in the very good category and in the results of the assessment of lecturer 2, the average is 87%, which is included in the very good category. Suggestions can be presented in **Table 9** below.

Table 9. Results of Suggestions from Food Microbiology Lecturers

Suggestion	Information
• Must be more consistent in the use of words • Sentences used must be more understandable by students	Fixed

Textbooks that have been assessed by the lecturer in charge of food microbiology after being revised are tested in individual groups, small groups and large groups. The results as well as suggestions and follow-up can be presented in **Table 10** below.

Table 10. Results of individual, small and limited group trials

Assessment Aspects	Individual Group Trials (%)	Small Group Trial (%)	Limited Group Trials (%)
Display of Teaching Materials	83	87	92
Concept Mastery	83	90	87
Learning Activity	86	86	88
Increased Affective Awareness	86	94	89
Obtaining Sources of Information	92	86	83
Average	**85**	**89**	**89**
Criteria	**Very Good**		

The average results of the individual group trials, namely 85%, are in the very good category, the results of the small group trials, namely 89%, are included in the very good category, and the results of the limited group trials, the average is 89%, are included in the very good category. Suggestions can be presented in **Table 11** below.

Table 11. Results of suggestions and follow-up of individual, small and limited group trials

Assessment Aspects	Suggestion	Information
Individual group	• The language used should be simplified again so that it is easy to understand • The image listed is still minimal so that it is added again • Add practice questions for each chapter • Add a concept map	Fixed
Small group	• There are still image captions that are not listed • The use of words is still inconsistent so that attention is paid again	Fixed
Limited groups	• Pay attention to the design of textbooks to make them more attractive • Color combinations are aligned again • Use language that is more understandable	Fixed

4. Implementation Stage

The implementation phase is carried out by applying the textbooks that have been developed to students. At this stage students are given a pretest and posttest to find out whether students have increased critical thinking skills. In the experimental class students were given case-based food microbiology textbooks while in the control class they were not given case-based food microbiology textbooks. The pretest average value in the experimental class was 50.13 and the posttest average value was 81.46. While the pretest average value in the control class was 46.3 and the posttest average value was 72.2. The t-test results obtained in the experimental class and control class were 0.000 (2-tailed) <0.05 so it can be concluded that there is a significant difference. This shows that there is a significant effect on the treatment given before the pretest and after the posttest. The average N-gain value obtained in the experimental class given a food microbiology textbook, namely 62.56, was included in the moderately effective category. Meanwhile, the average N-gain score for the control class without being given a food microbiology textbook was 42.28, which was included in the less effective category. Based on the N-gain test, it can be concluded that the use of case-based food microbiology textbooks has a fairly good level of effectiveness in increasing critical thinking skills.

5. Evaluation Stage

The stages of evaluation in the research carried out were formative and summative evaluations. The formative evaluation activities carried out included material validation, media validation and trials. This is in accordance with Arikunto formative evaluation is an evaluation carried out when the program is still ongoing or when it is still close to the start of the activity. It was found that after being assessed by the validator and revising, the final result was a practicum guide that was feasible to try out. The results of the trials conducted in small groups and large groups received suggestions from students and were then revised according to the suggestions. Then a summative evaluation was carried out at the implementation stage, the results showed that students' critical thinking skills increased with the guidance.

3.2 Discussion

At the analysis stage, a needs analysis and material analysis were carried out for biology students. Analysis of student needs was in the form of finding relevant learning materials, analyzing the quantity of textbooks used[7]. The results of the analysis obtained are that biology education students class of 2018 need learning media that are practical, effective, innovative, and efficient in accordance with current technological advances so that they can make students learn independently and improve critical thinking skills. In addition, students also need a teaching and learning process that is not limited by space and time. Therefore, media is needed that can help meet the needs of students.

The next stage is design. At the design stage what was done was to design a case-based food microbiology textbook. This design stage is carried out prior to development[8]. The next stage is the product development stage through the validation process of material experts, learning technology and language. The purpose of product validation is to get textbooks that are feasible to use. Case-based food microbiology textbooks were developed in accordance with the structure of textbooks, which included covers, titles, objectives, wise words, learning materials, case examples, exercises, summaries. The process of developing textbooks adapts to the instructional objectives of the course, then must collect various information from various literary sources, such as textbooks, scientific articles, journals and mass media[9]. Information is then packaged according to student needs, then arranged, packaged and written as teaching

materials using a systematic framework (Husamah, 2018). The content of the food microbiology textbook is prepared based on the existing curriculum in the Biology Study Program, Medan State University. The textbook material refers to Competency Indicators in the RPS for the Food Microbiology course for Biology students. In addition, the preparation of textbooks that are developed must have the principles of relevance, consistency, and adequacy[10].

In the process of validating textbooks that have been checked by the validator, they must go through revisions to improve the textbook. Revisions were made based on suggestions from the material validator which had been explained in the presentation of data and suggestions directly during discussions with the material expert validator[11]. On the content aspect, the material has been clarified by including relevant sources. Good material is according to the needs of students. According to Abidin[12] states that material is not given too little or too much, if too little or too much material is presented it will not help achieve competence. In the first stage of product media validation, it is necessary to revise based on the suggestions provided by the validator in the form of improving the material and learning design that has been prepared[13]. The developed textbook was suggested by the validator to correct the inappropriate images. This is in accordance with Atmawarni[14] which states that the use of images can be used as a reinforcement for the information presented.

The results of textbook development products that have been revised based on comments and input from media validators aim to improve textbooks so that they become more effective, efficient and communicative while taking into account the objectives of preparing the textbook[15]. Products that have been validated by the material validator, learning technology validator and language validator can be tested on students. The trials were carried out on limited groups of 21 students, small group trials of 9 students, and individual group trials of 3 people. The average results of limited, small and individual group trials were 89%, 89% and 85 % including very good criteria. This shows that from the average results the developed textbook products get a good response from students. Based on relevant research by Mawaddah[16] stated that the average percentage of the results of the assessment of textbooks by students in the group trial was 85.78% with very valid criteria. Another study conducted stated that the percentage of the total product according to students was 79.19% with feasible criteria[11]. This was also reinforced that from the trial results an average percentage of 81.36 was included in the high category so that it could be used as good teaching material in the learning process[17].

The next stage is the implementation of textbooks for students. This stage is the stage of implementing textbooks that have been designed previously[18]. At the implementation stage, a pretest and posttest were carried out on students. The objective was to conduct a pretest and posttest to find out whether the textbooks being developed were able to improve critical thinking skills or not. This was done for the experimental class and the control class with the number of questions given, namely 25 multiple choice questions.

The scores from the pretest and posttest will be analyzed by using the Sample t-test and the N-gain score test. The average N-gain score in the control class was 46.28. This indicates that in general the level of effectiveness of teaching food microbiology using textbooks is in the poor category. Based on these data it can be concluded that the use of case-based food microbiology textbooks is quite effective and able to improve critical thinking skills and problem solving of students in the experimental class. In line with these data, in his research stated that in training critical thinking skills it is necessary to get used to critical analysis of

information and problem solving[19]. The results of this study are supported which states that one way to cultivate critical thinking skills is to carry out a learning process using books as a learning resource that can direct students to think and be able to solve problems.

The questions contained in the book are not limited to the ability to remember or just understand, but the questions and assignments arranged in the textbook must be able to train students' critical thinking skills and problem solving. In the textbooks presented there is a stimulus which stimulates students to think critically. With the components of critical thinking in textbooks, it can create effective learning and improve students' critical thinking skills and problem solving. Therefore, to get maximum results, train thinking skills Student critical thinking requires quite a long time[20].

4 Conclusion

The research that has been carried out produces a case-based food microbiology textbook to improve the critical thinking skills of biology students with very good criteria from material validators, learning technology validators, language validators, lecturer responses and has gone through an individual, small and limited trial process so that it is appropriate with the material needs and characteristics of students.

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