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Development of a Genetics Textbook Integrating Local Observational Case Study Assignments to Support Critical Thinking and Problem-Solving Skills

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ABSTRACT

Students' understanding of genetic concepts is often hindered by the abstract and complex nature of the material, particularly because genetic processes occur at the molecular level and cannot be directly observed. Based on a preliminary survey conducted in the Biology Education Program at UIN Jurai Siwo Lampung, most students perceive genetics as a difficult and overly theoretical subject. This study aims to develop a genetics textbook integrated with local case study observation assignments to enhance students' critical thinking and problem-solving skills. The research employed the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation), involving expert validation by content and media specialists, as well as a limited trial with students. The instruments used included validation sheets and student response questionnaires, which were analyzed quantitatively using a Likert scale and percentage of achievement. Validation results showed that the product received a score of 92% from the content expert and 85.3% from the media expert, both categorized as "Highly Appropriate." The trial with students yielded an average score of 83.9%, falling under the "Highly Practical" category. The study concludes that the genetics textbook based on local case studies is valid and practical for helping students understand abstract genetic concepts in a contextual manner, while also supporting the development of critical thinking and problem-solving skills.

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INTRODUCTION

Currently, education in Indonesia has entered the 21st century learning where technology and information are developing rapidly and have an impact on all aspects of life, including education (Mardhiyah et al., 2021). The focus of the 21st century learning system is to equip students with "The 4C Skills" or skills in thinking and learning in the 21st century (Nabilah and Nana, 2020). One of the skills that students must have is critical thinking skills and *problem solving* which is in line with one of the learning focuses in the curriculum (Tumanggor, 2021). So it is very important for educators to improve students' critical thinking skills, especially in biology learning (Astuti et al, 2022).

To develop critical thinking and problem-solving skills, continuous practice is essential in order to cultivate these skills as positive habits (Dharmono et al., 2019). In facilitating such ongoing training, educators are required to be more creative and innovative in utilizing instructional media to prevent students from becoming disengaged or bored. Innovation in designing interactive and engaging learning media is necessary to effectively connect the subject matter with students as learners, thereby enhancing the quality of educational development and learning (Riefani, 2019; Septiani et al., 2020; Aulia et al., 2021).

Biology learning, as a scientific discipline, cannot be separated from hands-on and minds-on activities that involve both practical and cognitive skills (Solika & Susantini, 2022). Biological content is characterized by being both concrete and complex. This inherent complexity often presents challenges for students, as it requires a high level of abstraction and an understanding of interrelated concepts (Roemintoyo & Budiarto, 2021). One of the most conceptually demanding topics is genetics, which forms part of the high school biology curriculum. Within this topic, genetic substances are particularly difficult to grasp because they encompass the structure and function of DNA and RNA, as well as inheritance mechanisms—concepts that cannot be directly observed. The abstract nature of molecular processes such as replication, transcription, and translation, combined with the lack of direct visual access to these biological phenomena, contributes to students' difficulties in fully conceptualizing them (Rianti et al., 2022).

To address these challenges, developing a genetics textbook for biology education students is essential as an instructional tool. The textbook is designed to support the visualization and concretization of abstract genetic concepts—especially those related to DNA, inheritance, and gene mutation—through the use of contextual case studies. These case studies are drawn from

real-life phenomena within the students' immediate environment, thereby enabling them to connect theoretical knowledge with meaningful, practical experiences. As a result, students are expected not only to gain a theoretical understanding of genetic principles but also to apply them effectively in both academic and real-world contexts. Case studies on genomic imprinting have been shown to significantly improve students' conceptual understanding, as post-intervention scores on true/false assessments were substantially higher than pre-test results, and students reported increased comprehension and enjoyment of the learning process (Goudsouzian & Lo, 2023). This supports the use of real-world scenarios from the students' environment to make abstract ideas more accessible.

Similarly, Donovan et al. (2020) conducted a randomized-controlled trial involving 9th–12th graders, finding that enhanced 'genomics literacy' through contextualized genetics education reduced students' misconceptions—such as genetic essentialism—by enabling conceptual shifts after learning about human genetic variation. This underscores the importance of instructional designs that foster deep understanding via contextualized learning. These findings validate the design of our textbook: embedding case studies from the students' immediate environment enables them to relate theoretical knowledge to authentic, meaningful experiences. As a result, students not only achieve theoretical comprehension of genetic principles but also develop the ability to apply these concepts effectively in both academic and real-world contexts.

In addition, the results of a preliminary survey conducted among 5th and 6th-semester biology students at UIN Jurai Siwo Lampung—using questionnaires and interviews—showed that genetics is perceived as a difficult and abstract subject. Students stated that the complexity stems from the fact that genetic processes occur at the molecular level and cannot be directly observed with the human senses. Moreover, 55% of respondents indicated that genetics is heavily loaded with theories, laws, and memorization, which makes the learning experience feel burdensome. These findings provide a clear indication that students struggle not only with the content but also with how it is presented. Therefore, it is essential to develop learning materials that can help bridge the gap between abstract theory and meaningful, concrete understanding. One effort to address this issue is through a development research project titled Development of a Genetics Textbook Integrating Local Observational Case Study Assignments to Support Critical Thinking and Problem-Solving Skills.

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The genetics textbook developed in this study offers a novel approach by integrating local case studies, an initiative that appears to be relatively unexplored within the context of genetics education in Indonesia. This innovation not only contextualizes learning but also enhances student engagement and comprehension by relating abstract genetic concepts to familiar, real-world scenarios. The incorporation of local case studies into the textbook serves to bridge the gap between theoretical knowledge and practical application, making the learning experience more relevant and meaningful for students. By situating genetic principles within the framework of local phenomena, students are better equipped to understand and retain complex information. This approach aligns with contemporary educational strategies that emphasize contextual and culturally responsive teaching methods

RESEARCH METHODS

This study employed a development research design based on the ADDIE model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected for its structured approach in guiding the instructional material development process, particularly for creating a contextually relevant genetics textbook integrating observational local case study assignments. Each stage of the model was applied sequentially, ensuring alignment between the learning objectives, the needs of the students, and the instructional strategies.

This development research adopts the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), a systematic framework widely used in instructional design to produce effective and contextually relevant learning materials. The ADDIE model has been shown to be effective in various recent studies, including those involving microlearning content development for software engineering courses (Dilaines, L. E., Astuti, E., & Yusdita, E, 2024). By adopting the ADDIE model, this study aims to produce a genetics textbook based on local case studies that is not only aligned with the curriculum but also culturally and contextually relevant for Indonesian students. This approach is expected to enhance learning effectiveness and foster greater student engagement in mastering genetic concepts.

The subjects of this study were undergraduate students from the Biology Education Program, class of 2022, at UIN Jurai Siwo Lampung. The sampling technique used was purposive sampling, as the selected students were considered appropriate for evaluating the instructional product due to their academic background and the relevance of the material to their coursework.

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To evaluate the quality of the developed textbook, the researcher employed a questionnaire instrument. This instrument was designed to assess three primary aspects: Validity, referring to the accuracy and appropriateness of the content; Practicality, referring to the ease of use and implementation of the textbook in classroom settings; Effectiveness, referring to the impact of the textbook on students' understanding and engagement with genetics concepts. Each of these aspects was measured using indicators adapted from relevant theoretical frameworks and validated through expert review.

Data in this study were collected using several techniques, tailored to each development stage. During the needs analysis phase, data were obtained through interviews and document studies to identify learning gaps and relevant local contexts. In the product validation stage, data were collected through questionnaires completed by content and media experts. During the trial phase, questionnaires were also distributed to students to gather feedback on the practicality and effectiveness of the product.

Data analysis was conducted using descriptive quantitative and qualitative methods. Quantitative data from the questionnaires were assessed using a Likert scale, and mean scores were calculated to determine the levels of validity, practicality, and effectiveness. Qualitative data, obtained from expert suggestions and student comments, were analyzed for product improvement. The product's eligibility criteria were based on score interpretation categories: Highly Appropriate, Appropriate, Moderately Appropriate, Inappropriate, and not Appropriate. The categories in the Likert scale assessment in this study can be seen in Table 1 below.

Table 1 Rating Categories for Likert Scale

Score	Category
1	Highly Inappropriate/Highly Impractical
2	Inappropriate/Impractical
3	Moderately Appropriate/Moderately Practical
4	Appropriate/Practical
5	Highly Appropriate/Highly Practical

Modification from (Pranatawijaya, 2019)

The questionnaires used in this study were validated by two experts: one in content and one in media. Validation focused on the appropriateness of the content, construction, and readability of the instrument. Revisions were made based on expert input to ensure that the instrument could accurately and reliably measure the intended aspects. After the score is obtained, it is then

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calculated to determine the suitability of the product to be used in the learning process. For the number of assessment items in the material expert and media expert validator questionnaire, it can then be presented using the formula:

$$Percentage\ of\ Achievement = \frac{Total\ score\ obtained}{Maximum\ score} \times 100\%$$

Evaluation categories for material expert validators and media experts can be seen in Table 2 below.

Table 2 Rating Categories for Material Expert, Media Expert, and Response Student

No	Score Range	Category
1	80 – 100	Highly Appropriate/Highly Practical
2	60 – 79,9	Appropriate/Practical
3	40 – 59,9	Moderately Appropriate/Moderately Practical
4	20 – 39,9	Inappropriate/Impractical
5	0 – 19,9	Highly Inappropriate/Highly Impractical

RESEARCH RESULT

The outcomes of the development process are presented in this section before the validation and testing phases are discussed. These outcomes include the initial design, structure, features, and content of the developed genetics textbook based on local case studies. The product resulting from this research and development is a genetics textbook based on local case studies, developed as a biology teaching medium for the genetics course of Biology Education students at UIN Jurai Siwo Lampung, aimed at facilitating the development of critical thinking and problem-solving skills among the students. The developed genetics textbook uses the ADDIE development model. The product development process follows the ADDIE model, which consists of five stages, as outlined below:

Analysis

In this initial stage, observation and data collection are carried out to assess the needs of the students in order to identify potential issues and appropriate solutions for the learning process. The analyses conducted in this stage include the following aspects:

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Curriculum Analysis

The Biology Education Program at UIN Jurai Siwo Lampung utilizes the Merdeka Belajar Curriculum in the 2022/2023 academic year. In this curriculum, lecturers serve as facilitators, mediators, motivators, and inspirers, while students are positioned as active participants in the learning process.

Student Needs Analysis

Based on the interviews conducted, it was found that 70% of the students agree to use a genetics textbook based on local case studies in the genetics course to facilitate their learning process both inside and outside the classroom.

Biology Material Analysis

Genetics material in this course is not limited to reading and memorizing. Students are required to study subtopics that are related to everyday life. The developed genetics textbook based on local case studies is expected to facilitate the achievement of course objectives and meet the students' needs. Each chapter of the textbook is accompanied by a local case study that is directly related to the core material and concepts presented in that chapter. Students are given one activity per chapter that instructs them to observe and analyze a real-world problem or case relevant to the discussed topic. A structured report template is provided within the textbook to guide students in documenting the issue, analyzing its alignment with the assigned investigative task and theoretical concepts, and drawing conclusions. Following the analysis, students are required to propose preventive and responsive solutions to the case based on relevant research findings and theoretical foundations covered in the chapter. This activity aims to encourage students to apply genetic concepts to local phenomena, thereby enhancing critical thinking and problem-solving skills through contextual and meaningful learning.

Formulating Objectives

The development of each chapter's material in the genetics textbook based on local case studies is aligned with the learning objectives outlined in the Lesson Plan for the genetics course in the Biology Education Program at UIN Jurai Siwo Lampung. The researcher hopes that the development of this genetics textbook based on local case studies will meet the needs of students in the Biology Education Program at UIN Jurai Siwo Lampung for the genetics course. This textbook is expected to be used by both students and lecturers in the learning process and can also be utilized for learning outside the classroom.

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Design

After analyzing the problems and needs of students, the next stage is the design stage which is the stage of designing the genetics textbook product that will be created. The steps at this stage include:

a) Compile the content of genetics textbook products starting from chapter 1 to chapter 10 in accordance with the lesson plan for genetics courses at the Biology Education Program of UIN Jurai Siwo Lampung.
b) Determine the type and size of letters that will be used in the genetics textbook product that will be made.
c) Determine the paper size and type of paper that will be used in genetics textbook products. The paper size used is B5 with 150g art paper.
d) Make a design *cover* and design *layout* on genetics textbook products.
e) Compile the contents of a genetics textbook starting from *cover* foreword, foreword, table of contents, list of figures, chapters 1 to chapter 10, bibliography, glossary, author's history, and *cover* back.

Development

At this stage, the development of the genetics textbook was carried out based on the previously designed framework. The development phase in this study consisted of: (a) the creation of product; and (b) the validation testing of the product.

Creation of Product

In this development phase, the genetics textbook design was printed using the specified paper type and size determined in the earlier stage. Once the printing process was completed, the genetics textbook was bound in the format of a standard book. Subsequently, the textbook media was validated by experts, consisting of a content expert and a media expert. In this study, the content expert validator was Mrs. NH., and the media expert validator was Mrs. FP. After validation was completed and the product was deemed appropriate, it was then tested on students during the implementation stage. Once all components of the textbook were finalized, the book was prepared for printing in B5 size. A digital link to the textbook was then distributed to the team of expert validators for evaluation in terms of content and media.

Product Validation Tests

The validity testing process for both the developed product and the research instruments was conducted through assessments provided by expert validators. The researcher submitted a

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validation sheet along with the developed product, which was subsequently evaluated. In addition to assessing the product itself, the validators also evaluated the research instruments used during the study. In this research, the content expert was Mrs. NH, and the media expert was Mrs. FP. After validation and approval, the product was deemed feasible and was subsequently tested on students during the implementation stage. The research results, presented in the form of data, are displayed in three graphs and are described as follows. Graph 1 presents the comparison of validation results by material experts. Graph 2 presents the comparison of validation results by media experts. Graph 3 shows the results of student responses from the product trial.

Material Expert Validation Results

Material validation aims to assess the relevance and identify potential shortcomings in the content of the developed product. In this process, the material expert validator for the genetics textbook based on local case studies was Mrs. NH. The validation was conducted in two stages. Based on the percentage results from both stages of validation, a graph was produced, as shown in Figure1 below.

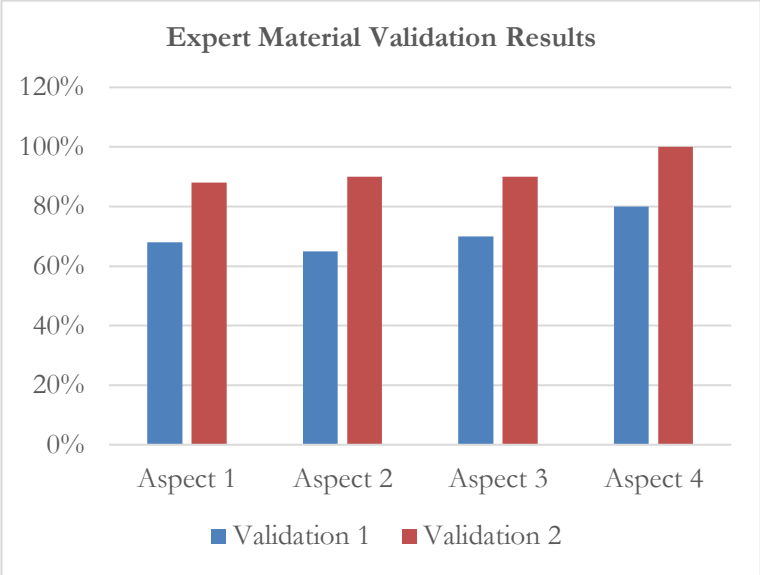

Figure 1. Graph of Material Expert Validation Results

Details:

Aspect 1 : Material Quality
Aspect 2 : Grammar Feasibility
Aspect 3 : Feasibility of Presenting the Content of Teaching Materials
Aspect 4 : Suitability of the Genetics Teaching Materials to Problem-Based Learning Indicators and Problem-Solving Skills

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The results of the first validation conducted by material experts yielded a percentage of 71%, placing it in the "Appropriate" category. Although this falls within the feasible range, revisions are necessary based on the suggestions and feedback provided by the material expert validator. Upon completion of the revisions, the product was resubmitted to the material expert validator for a second round of validation.

The results of the second validation, carried out by material experts, yielded a percentage of 92%, placing it in the "Highly Appropriate" category. This improvement reflects an increase in product feasibility from 71% to 92%. The second validation did not yield any further suggestions for improvement, and as a result, the genetics textbook based on local case studies was deemed suitable for testing without further revision.

Media Expert Validation Results

Media validation aims to assess the suitability and identify any shortcomings in the visual presentation of the product being developed (Appendix 4). In this process, Mrs. FP, served as the media expert validator for the genetics textbook based on local case studies. This validation stage was conducted in two rounds. Based on the percentage results from the first and second stages, a graph has been produced, as shown in Figure 2 below:

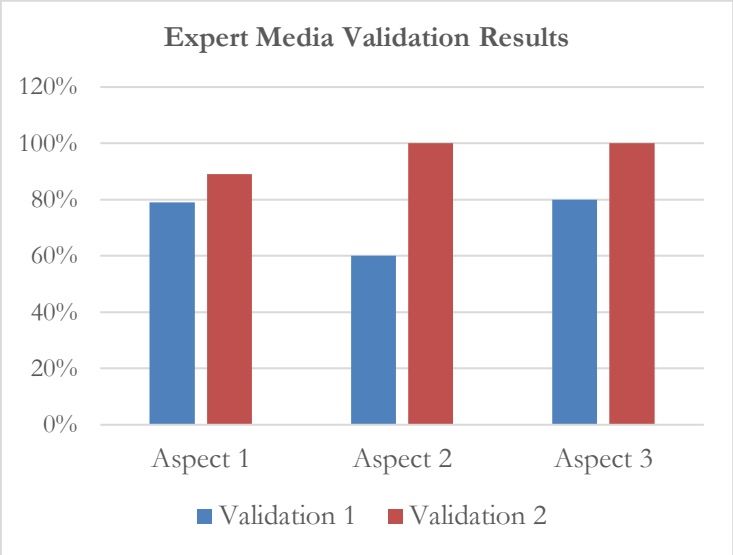

Figure 2. Graphic of Media Expert Validation Results

The results of the first validation conducted by media experts yielded a percentage of 77%, placing it in the "Appropriate" category. Although this falls within the "Moderately Appropriate" range, revisions are necessary based on the suggestions and feedback provided by the media expert validators. After the revisions were made, the product was resubmitted to a media expert for a

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second round of validation. The results of the second validation, carried out by media experts, yielded a percentage of 85.3%, placing it in the "Highly Appropriate" category. This improvement reflects an increase in product feasibility from 77% to 85.3%. The second validation did not yield any further suggestions for improvement, and as a result, the genetics textbook based on local case studies was deemed suitable for testing without further revision.

Testing Phase (Implementation)

The product trial phase was conducted after the genetics textbook based on local case studies, which had been developed, was deemed feasible by material and media experts. Subsequently, the product was tested on Tadris Biology students who had completed the genetics course. The results of the responses from the Tadris Biology students who had taken the genetics course can be seen in Table 3 below:

Table 3 Student Response Results

No	Statement	Average Score	Category
1	The material is presented comprehensively	89%	Highly Practical
2	The delivery of the material in the genetics textbook based on local case studies is related to everyday life	85%	Highly Practical
3	The language used is clear and easy to understand	78%	Practical
4	The images used are appropriate to the content	90%	Highly Practical
5	The design of the genetics textbook based on local case studies is engaging	92%	Highly Practical
6	The layout of text and images is appropriate/attractive	80%	Highly Practical
7	The use of font variations is not excessive	85%	Highly Practical
8	The separation between paragraphs is clear	80%	Highly Practical
9	The images are realistic/true to life	85%	Highly Practical
10	The material can be studied anywhere and anytime	75%	Practical
	Total Average Score	**83,9%**	**Highly Practical**

The product trial phase was conducted after the genetics textbook based on local case studies, which had been developed, was deemed feasible by material and media experts. Subsequently, the product was tested on undergraduate biology students who had completed genetics courses. The results of the responses from Tadris Biology students who had taken the genetics courses are presented below. The student testing phase was carried out only once, involving the analysis of student responses to the developed media. The average score of the overall student responses to the genetics textbook based on local case studies was 83,9%, placing

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it in the "Highly Practical " category. Based on these trial results, the product was deemed ready for use without the need for further testing and is suitable for use as a learning medium for students.

The validation and testing results of the genetics textbook based on local case studies are summarized in Figure 3 below:

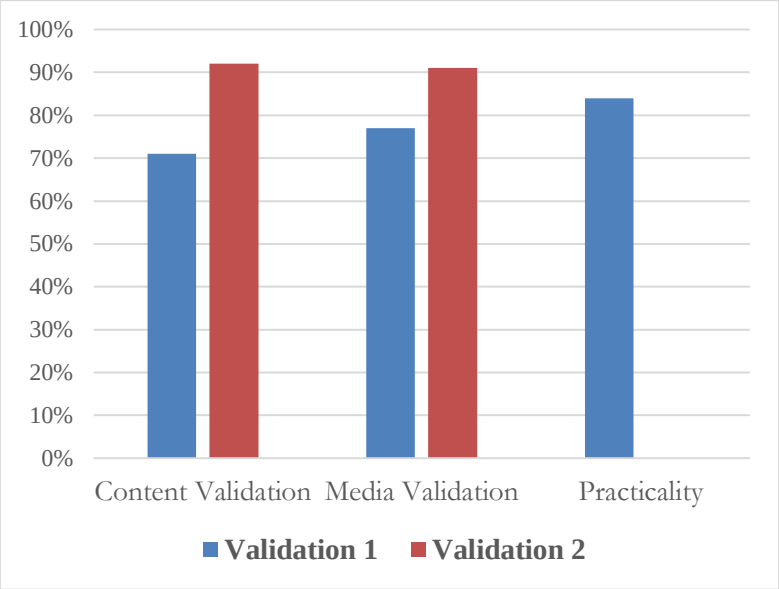

Figure 3 Graph of Overall Results of Validation and Testing of Textbook Products Genetics Based on Local Case Studies

Evaluation

The evaluation stage was carried out to measure the feasibility and improve the quality of the genetics textbook product being developed. At this stage, revisions are made to the product in accordance with suggestions and comments provided by material expert validators, media experts and students. Revisions are carried out until the genetics textbook product is declared suitable for use.

The final product review is the outcome of the development of the case-based genetics textbook. In research methods, it has been explained that the product development follows the ADDIE development model, which consists of the stages of analysis, design, development, implementation, and evaluation. Below is the final product display: the front and back covers of the genetics textbook, as shown in Figure 4.

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Figure 4 Front Cover and Back Cover

The product revision process was carried out in two stages: expert revision and revision after the trial was conducted with the research subjects. After passing through the revision stages, the final product was obtained, meeting the criteria of validity dan practicality.

DISCUSSION

The development of a genetics textbook based on local case studies has demonstrated that the resulting product meets the criteria of validity, practicality, and effectiveness. Validation by subject matter experts yielded a score of 92%, while validation by media experts reached 85.3%. Both are categorized as "Highly Appropriate," indicating that the content and media presentation of the textbook align with instructional needs and the standards for developing digital learning materials. These findings are consistent with previous research, which emphasizes that expert involvement in product validation plays a crucial role in ensuring the quality of both instructional content and media (Hamdani & Rokhmat, 2021; Nurhikmah et al., 2022).

Furthermore, the results of student feedback from product trials showed an average score of 44.5, with a practicality percentage of 83.9%, also categorized as "Highly Practical." This indicates that the product is not only academically sound but also well-received by the target users, namely university students. The positive responses suggest that the textbook effectively supports students in understanding genetic concepts, particularly because it integrates real-life case studies that are relevant to their local context. This aligns with contextual and problem-based learning approaches, which have been shown to enhance critical thinking and problem-solving skills (Fitriyani & Rusdi, 2020).

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This evaluation stage was conducted after the product had been declared feasible by both content and media experts, followed by trials involving students in the Biology Education Program at UIN Jurai Siwo Lampung who had previously completed the genetics course. The purpose of this trial was to assess students' responses regarding the practicality of the textbook, conducted by distributing the textbook along with evaluation questionnaires. Based on the data analysis, it was found that the product could be used without further revision and function optimally as a learning medium. These findings are supported by the development of a case study-based module on genetic material for high school students, which showed that local case-based learning significantly improves students' understanding and engagement (Kadir & Arsal, 2023).

The success of this textbook development is closely linked to the use of local case studies, which enable students to connect abstract genetic concepts with real-world phenomena in their immediate surroundings. The active involvement of students in observing, analyzing, and solving locally relevant problems fosters higher-order thinking skills. This approach is grounded in constructivist theory, which emphasizes the importance of learners actively constructing knowledge through direct and contextual experiences.

Moreover, the local case-based approach adds innovative value to the textbook, as such strategies remain relatively unexplored in genetics education within Indonesia. By linking genetics content with actual local issues, students are better able to understand and retain abstract concepts and apply them in real-life situations. This strategy bridges the gap between rote learning and skills-based education, making the learning experience more meaningful and impactful.

These findings are further supported by related studies showing that integrating ethnoscience into biology learning enhances its relevance and meaning (Mariana, 2020). Similarly, the use of local science-based instruction at the Kalijaga Heritage Site has been shown to significantly improve students' critical thinking skills and classroom engagement (Wijaya et al., 2022). In addition, a case-based food microbiology textbook was developed and shown to be effective in enhancing students' critical thinking, as evidenced by positive feedback from both instructors and learners (Harun et al., 2023).

Nevertheless, this study has certain limitations, including the narrow scope of participants limited to students from a single institution—and the absence of experimental testing to measure the textbook's effectiveness. Thus, future research is recommended to expand the participant pool and adopt a quasi-experimental design to evaluate the impact of the product on student learning

outcomes more comprehensively. In conclusion, the genetics textbook based on local case studies contributes meaningfully to the development of innovative instructional materials in biology education. It particularly supports the enhancement of students' scientific literacy, critical thinking, and problem-solving abilities. The product aligns with the current direction of higher education, which emphasizes contextual, culturally responsive, and student-centered learning approaches.

CONCLUSION

The development of a genetics textbook based on local case studies to enhance the critical thinking and problem-solving skills of biology students at UIN Jurai Siwo Lampung was carried out using the ADDIE development model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. The final product includes key components such as the front cover, foreword, table of contents, list of figures, ten chapters of instructional content, bibliography, author biography, and back cover.

The validation process conducted by subject matter experts and media experts produced highly satisfactory results, with scores of 92% and 85.3%, respectively—both categorized as "Highly Appropriate." Additionally, the results of the product trial involving students showed an average score of 44.5 and a practicality percentage of 83.9%, which also falls under the "Highly Practical" category. These findings indicate that the developed textbook is not only academically and technically feasible without the need for further revisions but also effective in supporting the learning process. Overall, the textbook has proven to facilitate the understanding of abstract genetic concepts through a contextual approach based on local case studies. This product demonstrates strong potential as an innovative learning medium that supports the development of scientific literacy as well as students' higher-order thinking skills in genetics education.

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