

DEVELOPMENT OF A BIOLOGY TEXTBOOK FOR GRADE XII ON HUMAN HEREDITY MATERIAL USING THE SCIENTIFIC APPROACH

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Abstrak

Bahan ajar berperan penting dalam pendidikan untuk mendukung pembelajaran yang sistematis, mendorong kemandirian peserta didik, dan mengurangi ketergantungan pada guru. Buku ajar Biologi yang sudah ada belum sepenuhnya mendukung pendekatan saintifik dan pembelajaran mandiri, khususnya dalam Materi Hereditas pada Manusia. Penelitian ini bertujuan untuk mengembangkan buku ajar Materi Hereditas pada Manusia dengan scientific approach yang memenuhi kriteria kevalidan dan reliabilitas bagi peserta didik di tingkat SMA/MA. Penelitian ini menggunakan metode *research and development* (R&D) model 4D namun hanya menerapkan tiga tahap pertama (*define, design, dan develop*). Pada tahap *develop*, dilakukan modifikasi dengan penambahan tahap evaluasi berdasarkan model Tessmer. Validasi buku ajar dilakukan oleh dosen dan guru biologi, sementara uji coba awal dilakukan pada sejumlah guru biologi kelas XII. Hasil validasi menunjukkan bahwa seluruh aspek buku ajar dapat dinyatakan layak digunakan, dengan tingkat validitas dan reliabilitas yang memenuhi standar yang ditetapkan. Respons guru juga menunjukkan kategori sangat tinggi yang menandakan bahwa buku ajar ini layak untuk dilanjutkan ke tahap uji coba kelompok kecil dan uji lapangan untuk mengukur efektivitasnya sebagai bahan ajar. Penelitian ini berkontribusi dalam menyediakan bahan ajar yang valid dan reliabel untuk mendukung pembelajaran mandiri serta penerapan pendekatan saintifik di tingkat SMA/MA.

Kata Kunci: Buku ajar; Model 4D; Materi Hereditas pada Manusia; *Scientific approach*

Abstract

Teaching materials play a crucial role in education by supporting systematic learning, fostering student independence, and reducing reliance on teachers. Existing Biology textbooks do not yet fully support the scientific approach and independent learning, particularly in the topic of Human Heredity. This study aims to develop a Human Heredity textbook incorporating a scientific approach that meets the validity and reliability criteria for high school (SMA/MA) students. The research follows the research and development (R&D) 4D model but applies only the first three stages: define, design, and develop. In the development stage, modifications were made by adding an evaluation phase based on Tessmer's model. The textbook was validated by university lecturers and biology teachers, while an initial trial was conducted with a group of twelfth-grade biology teachers. The validation results indicate that all aspects of the textbook are deemed suitable for use, with validity and reliability levels meeting established standards. Teacher responses also fell into the highest category, suggesting that the textbook is suitable for further small-group trials and field testing to assess its effectiveness as a teaching resource. This study provides valid and reliable teaching materials to support independent learning and the scientific approach in high school education.

Keyword: Textbooks, 4D Models, Material on Heredity in Humans, *Scientific approach*

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INTRODUCTION

Textbooks play a crucial role in education as they assist teachers in delivering instruction and support students in the learning process (Depdiknas, 2008). One of the factors influencing the effectiveness of learning is the quality of the textbook. A good textbook should be systematically organized to enable students to learn in a structured manner and fully master the required competencies (Mulyasa, 2014). Moreover, textbooks should encourage students to be active and independent in acquiring knowledge. Therefore, instructional materials are needed that not only reduce students' dependence on teachers but also ensure their optimal engagement throughout the learning process (Magdalena et al., 2020).

One way to encourage students to be more active, creative, and capable of critical thinking during the learning process is by implementing specific approaches, such as the scientific approach (Lestari et al., 2018), problem-based learning (Maharani, 2015), project-based learning (Nedyana, 2017), and guided inquiry (Rahayu & Isnawati, 2019). In the 2013 Curriculum, the scientific approach is a key instructional requirement consisting of five stages: observing, questioning, collecting information, associating, and communicating (Kemendikbud, 2013). Meanwhile, in the Merdeka Curriculum, the scientific approach is applied through project-based activities with similar stages—observing, questioning, reasoning, associating, and communicating (Rohman & Muttaqin, 2022). This approach provides students with direct learning experiences through exploration and the development of scientific skills, thereby making learning more student-centered.

To evaluate the alignment of textbooks with curriculum requirements, interviews were conducted with 27 Grade XII Biology teachers from senior high schools (SMA/MA) in Pontianak and surrounding areas. The results revealed that the current textbooks do not fully reflect the scientific approach as expected. This finding is consistent with a survey by Izzatunnisa (2015) which indicated that the Biology textbooks used in schools remain largely informative and have not yet fully adapted to the curriculum. Therefore, the development of innovative textbooks is necessary to support independent learning. In this context, independent learning refers to an approach that provides students with greater freedom, responsibility, and authority in their learning process (Rhosalia, 2017), with the teacher acting as a facilitator rather than creating dependency.

Among the various topics in Biology, students often find genetics particularly difficult to understand. Several factors contribute to this perception, including the abundance of unfamiliar terminology, the complexity of the material, the need for mathematical calculations, and the requirement for logical reasoning (Knippels et al., 2005; Inayah, et al., 2020). Candramila & Waskito (2021) also found that internal factors—such as intuitive thinking, incomplete knowledge, and misconceptions—significantly affect students' understanding of genetic concepts. Moreover, the abstract nature of genetics makes it challenging for students to grasp the content through images or text alone in textbooks (Maulidi et al., 2014). As a result, genetics remains one of the most challenging concepts in Biology education.

The topic of Human Heredity in Grade XII Biology at senior high schools (SMA/MA) includes sex determination, blood types, and hereditary diseases. Based on interviews, seven Biology teachers in Pontianak reported that students often struggle with determining genotypes and identifying carriers in pedigree analysis (data unpublished). Preliminary observations of three textbooks used across 27 SMA/MA revealed that although the content aligns with the 2013 Curriculum, it does not implement the scientific approach or promote independent learning methods. Additionally, the unsystematic presentation of examples of inherited traits tends to encourage rote memorization rather than fostering deep conceptual understanding.

In both the 2013 Curriculum and the Merdeka Curriculum, students are expected to analyze patterns of inheritance in humans by constructing family pedigree charts. Therefore, it is necessary to develop Biology textbooks—particularly on the topic of Human Heredity—that apply the scientific approach to actively engage students and help them meet curriculum requirements. Numerous development studies have explored the use of electronic or digital learning materials (e.g., Ahyar et al., 2023; Prameswari et al., 2023; Martha et al., 2018). However, printed textbooks remain popular due to their practicality (Nazilah et al., 2014; Afriandi et al., 2020; Meidy et al., 2018).

This development research aims to describe the process of textbook development, evaluate the product's feasibility based on its validity and reliability, and identify teachers' responses to the results of a small-scale trial. The developed textbook is expected to meet the criteria of a quality instructional resource, including a clear structure beginning with the title, basic competencies and main material, supporting information, exercises, and ending with an assessment. It should also use appropriate language—namely, a semi-formal tone and standard sentence structures following the subject-predicate-object-adverbial pattern—and be engaging and motivating for students (Prastowo, 2015).

METHOD

This study employs the 4D development model by Thiagarajan et al. (1974) which consists of four stages: define, design, develop, and disseminate. However, the implementation of the 4D model in this research is limited to the first three stages—define, design, and develop. The develop stage is combined with Tessmer's (1993) formative evaluation, which includes expert review (expert validation) and one-to-one evaluation.

This research was conducted at the Faculty of Teacher Training and Education, Universitas Tanjungpura, as well as at SMAN 1, SMAN 3, SMAN 4, SMAN 7, SMAS Mujahidin, SMAS Islam Bawari, and SMAS Santun Untan in Pontianak City, from June 2023 to January 2024. In the define stage, the learning needs were identified and defined, and relevant information was gathered to support the development of the intended product. This stage was carried out through interviews with twenty-seven Grade XII Biology teachers from SMA/MA in Pontianak and surrounding areas.

Next, during the design stage, the product was planned based on the analysis results from the define stage. In the develop stage, the selection of the textbook format followed the steps outlined by Prastowo (2015), which include: 1) curriculum analysis, 2) title determination, 3) outline design covering all aspects related to competency achievement, and 4) textbook writing for the topic Human Heredity using the scientific approach.

The validation and trial stages of the developed textbook followed the formative evaluation process according to Tessmer (1993), which includes expert review and one-to-one evaluation. During the expert review stage, the feasibility of the textbook as instructional material for the Human Heredity topic using the scientific approach was tested. The textbook was validated by two Biology Education lecturers from FKIP Untan and three Grade XII Biology teachers from SMA Negeri 1 Pontianak, SMA Negeri 3 Pontianak, and SMA Negeri 7 Pontianak. Validators were selected based on a combination of academic experts and educational practitioners to ensure that the developed textbook is both conceptually valid and practically applicable.

The validation instrument referred to a modified version of Depdiknas (2008) and consisted of four aspects: presentation, content, language, and graphics, with a total of 16 assessment indicators. Next, the one-to-one evaluation involved individual testing to assess the intensity of

respondents' behaviors or feelings toward the developed textbook. This trial was conducted with four Grade XII Biology teachers from SMA Negeri 4 Pontianak, Mujahidin Private High School Pontianak, Islam Bawari Private High School Pontianak, and Santun Untan Private High School Pontianak. The selection of schools for the one-to-one evaluation was based on the variation in school types, institutional representation (public and private schools), respondent availability, and continuity with the previous evaluation stage. The response test instrument also referred to a modified version of Depdiknas (2008) covering four aspects—presentation, content, language, and graphics—with 21 assessment questions.

The data analysis in this study includes validation testing, reliability testing, and development trials through one-to-one evaluation. The textbook assessment by experts used a 4-point Likert scale, with scores of 4 (very good), 3 (good), 2 (not good), and 1 (very poor). The assessment instrument, adapted from a modified version of Depdiknas (2008) consisted of 16 statements evaluating the aspects of content, language, presentation, and graphics. Validation results were analyzed using Aiken's V formula to determine the level of agreement among evaluators for each assessed aspect (Azwar, 2012) as follows:

$$V = \frac{\sum s}{[n(c - 1)]} \quad (1)$$

Explanation:

s = r – lo

lo = the lowest validity rating score (in this case, 1)

c = the highest validity rating score (in this case, 4)

r = the score given by a rater

For five validators, the minimum standard value of Aiken's V that must be met using a 4-point rating scale is 0.87.

The validation results were also used to calculate reliability using the Intraclass Correlation Coefficient (ICC) to measure the agreement among raters (interrater reliability). The ICC calculation was performed using IBM SPSS Statistics version 26, and the reliability categories followed Koo & Li (2015) for a 95% confidence interval (see Table 1).

Table 1. Categories of Interrater Reliability Assessment Using ICC by Koo & Li (2015)

Assessment Category	ICC Value
Bad	ICC < 0,5
Medium	0,5 ≤ ICC ≤ 0,75
Good	0,75 ≤ ICC ≤ 0,9
Very Good	ICC > 0,9

The trial of the developed textbook was conducted by collecting responses from four teachers using a questionnaire. The questionnaire was rated on a Likert scale ranging from 4 (very good), 3 (good), 2 (fair), to 1 (very poor). The assessment instrument, adapted from Depdiknas (2008) with modifications, covered aspects of content, language, presentation, and graphics, comprising a total of 21 statements. The data were analyzed by calculating the scores for each statement selected by the respondents, then summing the total scores and determining the percentage of score attainment for each statement. The percentage of score attainment was calculated using the following formula:

$$P = \frac{\sum X}{\sum Xi} \times 100\% \quad (2)$$

The interpretation of the percentage of score attainment is based on the criteria from Riduwan (2015) (see Table 2). The textbook development is considered successful if the percentage of score attainment meets the criteria of high or very high.

Table 2. Item Response Criteria with Interpretation Criteria by Riduwan (2015)

Assessment Criteria	Score Interval (%)
Very Low	0-20
Low	21-40
Medium	41-60
High	61-80
Very High	81-100

RESULTS

The development steps of the textbook followed the 4D model by Thiagarajan et al. (1974). The define stage was used to determine development requirements and gather relevant information. This stage consists of five steps: preliminary-final analysis, learner analysis, task analysis, concept analysis, and formulation of learning objectives. The preliminary-final analysis was conducted through interviews with 27 Grade XII Biology teachers from senior high schools (SMA/MA) in Pontianak and surrounding areas to evaluate the alignment of the textbook with the syllabus, the 2013 Curriculum, and the Merdeka Curriculum. Learner analysis was based on Piaget's (1936) cognitive development theory, which states that Grade XII students (aged ≥ 11 years) are in the formal operational stage, enabling them to think abstractly—particularly relevant to the topic Heredity in Humans. This material includes sex determination, blood types, and inherited diseases, with references drawn from Campbell & Reece (2014), Hartl & Jones (1998), and Klug et al. (2012).

Table 4. Textbook Validation Results by 5 Validators per Indicator

Aspect	Assessment Indicator	Aiken's V Value	Average per Aspect	Description
Content	Alignment with basic competencies	1	0.88	Valid
	Relevance to students' needs	0.8		
	Relevance to instructional material requirements	0.87		
	Accuracy of content substance	0.87		
Language use	Readability	1	0.95	Valid
	Clarity of information	1		
	Compliance with Indonesian language rules	0.87		
	Appropriateness of language use for educational level	0.93		
Content presentation	Clarity of objectives	0.93	0.9	Valid
	Sequence of content presentation	0.93		
	Provision of motivation	0.87		
	Completeness of information	0.87		
Graphics	Use of font type and size	0.87	0.92	Valid
	Layout	0.93		
	Image display	0.87		
	Cover design appearance	1		

The design stage involved structuring the format of the textbook on Heredity in Humans using the scientific approach, based on Prastowo (2015). This format includes key elements such as the cover page, book identity, preface, table of contents, basic competencies, achievement indicators, concept map, main content, summary, competency test, bibliography, and glossary. The textbook also fulfills five essential components outlined by Prastowo (2015): title, basic competencies/main material, supporting information, exercises, and assessment.

In the develop stage, the textbook was created by drafting the content in Microsoft Word and designing visuals using Canva. The formative evaluation was conducted based on Tessmer (1993), which included expert review by five validators and one-to-one evaluation with four teacher respondents.

The evaluation of the textbook covered four main aspects: content, language, presentation, and visual design, with each aspect comprising four indicators (a total of 16 indicators). Detailed assessments for each indicator are presented in Table 4. The analysis results show that Aiken's V values for each statement ranged from 0.80 to 1.00. According to Aiken's V validity criteria (Azwar, 2012), statements scoring below 0.80 are considered invalid and require revision. One validator noted that the alignment of the textbook with students' needs still requires improvement, particularly in the way the material is presented to better match student learning characteristics. All validator feedback is presented in Table 5. For the remaining 15 indicators, validators confirmed that the textbook met the validity criteria. Although one indicator needs revision, the average validity score for the content aspect still met the minimum Aiken's V threshold (> 0.80) for the five validators. Therefore, the textbook is generally considered valid across most of the evaluated aspects.

Table 5. Validators' Comments and Suggestions on the Developed Textbook

Validator	Comments/Suggestion
Validator #1_Lecturer	The implementation of the scientific approach only covers 3 out of the 5 key steps. The "questioning" aspect should encourage students to ask questions, not merely answer them.
Validator #2_Lecturer	The concept needs to be re-proportioned, and the image of the blood type discoverer should not be displayed repeatedly.
Validator #1_Teacher	Scientific approach activities should be numbered to facilitate assignment.

The reliability of the validators' assessments was calculated using the Intraclass Correlation Coefficient (ICC). The ICC value for the single measure was 0.154, while the average measure was 0.686 (Table 6). These results indicate that individually, the reliability of the validators' assessments was low; however, overall, the textbook falls within the moderate category. There was a moderate level of agreement among the validators in evaluating the textbook. Nonetheless, the indicator concerning the suitability for students' needs still requires improvement, as indicated by the Aiken's V value.

Table 6. Intraclass Correlation Coefficient (ICC) Values from the Textbook Validation Results

	<i>Intraclass Correlation Coefficient</i>
	<i>Intraclass Correlation</i>
<i>Single Measures</i>	0,154
<i>Average Measures</i>	0,686

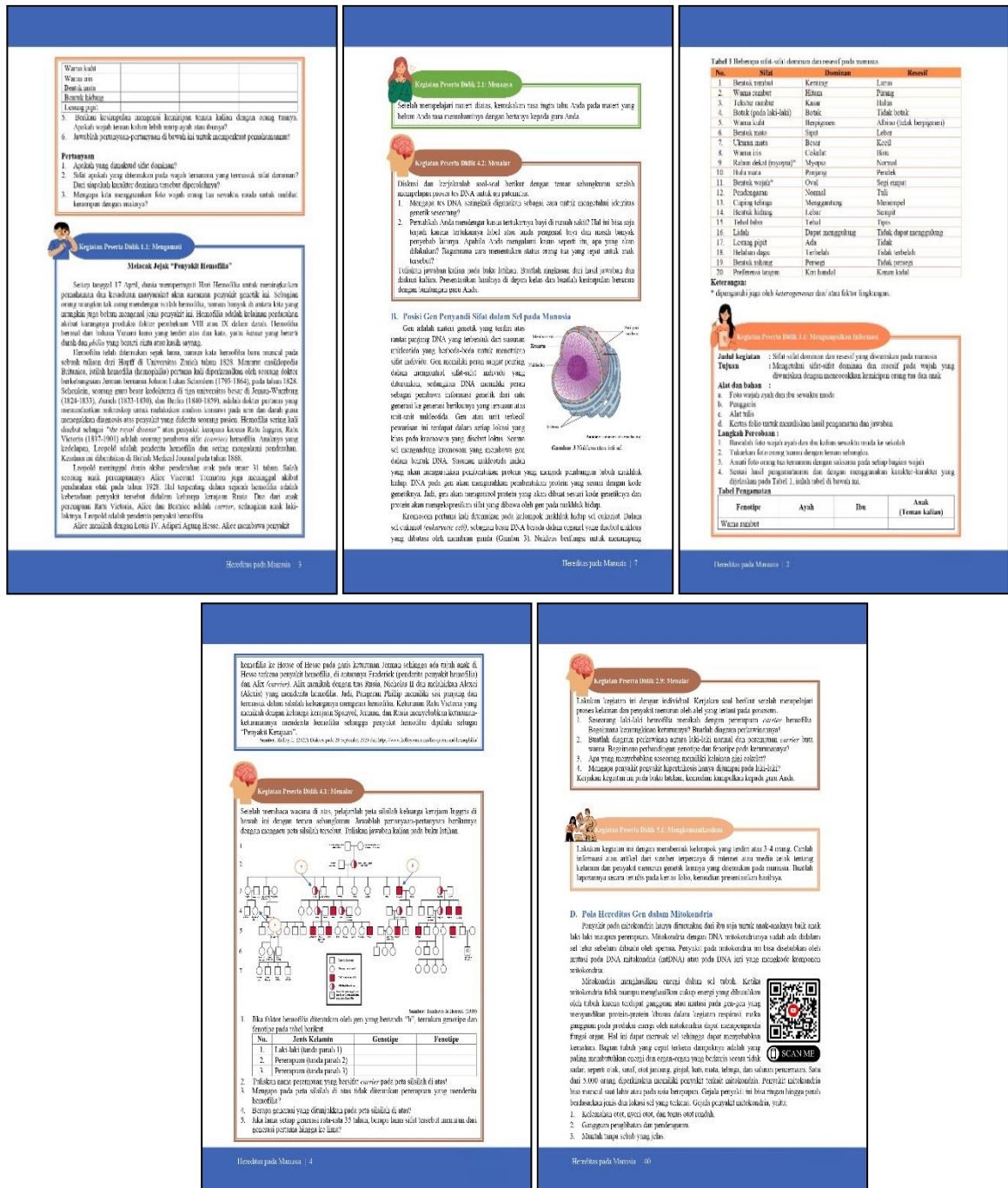


Figure 1. Layout of the Textbook on Heredity in Humans Using the Scientific Approach: A) Observing, B) Questioning, C) Gathering Information, D) Associating, E) Communicating.

After revisions to the indicator on alignment with students' needs, the textbook was tested through a one-to-one evaluation involving four senior high school biology teachers of Grade XII. This trial aimed to gather teacher responses regarding the content, language, presentation, and visual design of the scientific approach-based textbook developed in this study (Table 7). The response test results for all indicators fell into the "very high" category, with percentages ranging from 87.5% to 100%. The average response scores for each aspect were: content 93.75%, language 96.88%, presentation 94.53%, and visual design 97.5%—all within the "very high" category. Overall, the textbook received an average response score of 95.66%, categorized as very high.

Table 7. Responses of Four Teachers to the Developed Textbook by Indicator

Aspect	Indicator	Percentage (%)	Percentage Criteria per Indicator	Average per Aspect (%)	Criteria
Content	Alignment of the material with KD 3.7 and 4.7	100	Very High	93.75	Very High
	Incorporation of the scientific approach in the presentation of the material	93.75	Very High		
	Accuracy of the sequence of material presentation according to biological scientific concepts	87.5	Very High		
	Presentation of material that does not lead to misconceptions	93.75	Very High		
Language use	Use of easily understandable sentences	93.75	Very High	96.88	Very High
	Simplicity, focus, and communicativeness of the sentence structure used	93.75	Very High		
	Appropriate use of punctuation and sentence structure according to the EYD (Enhanced Spelling System)	100	Very High		
	Suitability of language with the cognitive development and emotional maturity of the students	100	Very High		
Content presentation	Breadth and depth of material to achieve basic competencies	100	Very High	94.53	
	Systematics and coherence of component presentation, from simple to complex concepts and from concrete to abstract	93.75	Very High		
	Support of the material presentation for independent learning	93.75	Very High		
	Accuracy and up-to-dateness of references	93.75	Very High		
	Inclusion of a clear table of contents with page numbers	100	Very High		
	Availability of material summaries for each key concept	93.75	Very High		
	Availability of evaluation questions to check mastery of the material	87.5	Very High		
	Availability of a glossary to help understand difficult terms	93.75	Very High		
Graphics	Readability and attractiveness of the font type and size used	100	Very High	97.5	Very High
	Proportional placement of all content components	100	Very High		
	Accuracy of images and illustrations to support material understanding	93.75	Very High		
	Suitability of images, text, and colors on the cover with the material concept	100	Very High		
	Excellence of print quality	93.75	Very High		

DISCUSSION

The development of the textbook, particularly on the topic of Human Heredity using a scientific approach, was successfully carried out. The textbook was created using Microsoft Word and Canva to ensure it is relatively familiar and accessible to many users. The title chosen for the textbook is "Book Chapter: Human Heredity Based on a Scientific Approach." The title "Human Heredity" aligns with the main topic in the syllabus of both the 2013 Curriculum and the Merdeka Curriculum, which covers patterns of human heredity as well as applications such as constructing family pedigree charts and case studies in various aspects of life, as stated in Basic Competencies 3.7 and 4.7 for the 2013 Curriculum and the Learning Outcomes for Phase F of Grade XII Senior High School in the Merdeka Curriculum.

The textbook contains various components, starting from the front title page, book identity, preface, table of contents, basic competencies, competency achievement indicators, concept map, introduction, main material, summary, competency tests, bibliography, to the glossary. The completeness of these content components is designed to provide explanations not only in terms of material but also to facilitate use by both teachers and students. For example, the concept map serves as a guide for students to understand the outline of the textbook's content. Concept mapping focuses more on organizing ideas, notes, or key points in the form of diagrams or charts as an effective learning technique (Zaghu et al., 2023).

Furthermore, the textbook equipped with competency achievement indicators helps students set clear learning targets as expected. According to Nurhasanah et al. (2019), guided learning aimed at specific targets makes it easier for students to achieve those goals optimally. The textbook is also supplemented with competency tests that further assist students in verifying their learning achievements. The variety of question types in the competency tests provides diverse cognitive challenges for students. Multiple-choice questions help deepen understanding by covering aspects such as remembering, understanding, applying, analyzing, synthesizing, and evaluating. Meanwhile, essay questions encourage students to organize, connect, and express ideas in writing (Juniar et al., 2014). The book size selected is A4, using Times New Roman font, with 1.15 line spacing, and margins of 2.5 cm at the top and bottom, 3 cm on the left, and 2 cm on the right. The chosen textbook format complies with ISBN and UNESCO standards.

The validation results of the textbook cover four main aspects: content, language, presentation, and graphics, with a total of 16 statements. Most indicators were deemed valid as they met the minimum Aiken's V value of 0.87. However, one indicator—content suitability to student needs—received a score of 0.80 and did not meet the validity criteria. Overall, the average scores for each aspect were: content 0.88, language 0.95, presentation 0.90, and graphics 0.92, with an overall average of 0.91, which falls into the valid category. These results indicate that the textbook meets the feasibility criteria based on the minimum Aiken's V value of 0.87 for five validators using a 4-point rating scale. The Aiken's V index itself is a measure of interrater agreement in assessing the suitability of items to the indicators being measured (Retnawati, 2016).

The content aspect of the textbook includes four assessment indicators: 1) alignment of content with basic competencies, 2) suitability of content to student needs, 3) relevance of content to teaching materials, and 4) accuracy of the material's substance. According to Choiriyah et al. (2022), a good textbook should present material systematically and adequately to achieve learning objectives and basic competencies. The presentation of the material in the developed textbook applies a scientific approach that integrates activities such as observing, questioning, collecting information, associating, and communicating. This approach is used to support students' understanding. In line with Triretnoningrum et al. (2025), selecting appropriate learning strategies

can influence learning outcomes. The scientific approach helps students become more active and critical during learning (Suprihatin et al., 2019). Additionally, this textbook is structured based on the syllabus of both the 2013 Curriculum and the Merdeka Curriculum, allowing it to meet teaching material needs more flexibly. Based on the validation results obtained for these four indicators, the textbook content can be considered valid with an average Aiken's V score of 0.88.

In the language aspect, the four assessment indicators include readability, clarity of information, conformity with Indonesian language rules, and appropriateness of language use according to the education level. The sentences in the textbook are considered clearly understandable, and the presentation of the material is easy to follow. Consistent with Syamsi et al. (2013), the language in textbooks should be concise and clear when giving instructions, explaining theories, and delivering tasks or exercises so that students can easily understand them. The sentences used should also be simple, to the point, and communicative. Readability in the textbook relates to comprehensibility, which is influenced by characteristics of words or sentences, such as paragraphs that are neither too long nor too short, and the frequency of sentence use, allowing readers to easily grasp the content when reading (Ginancar, 2020). Sentence construction in the textbook follows Indonesian language rules, such as the use of capital letters at the beginning of sentences, correct punctuation, and italicizing foreign words or scientific terms. The textbook's language use has also been adjusted to match the emotional development level of the students (Purnanto & Mustadi, 2016). Based on the validation results, these four language indicators are classified as valid, with an average score of 0.95.

In the presentation aspect, there are four assessment indicators: clarity of objectives, sequence of presentation, provision of motivation, and completeness of information. The material included in the textbook is broad and in-depth enough to enable the achievement of basic competencies for the topic. The textbook must consider principles that are important in determining the scope of learning material, including its breadth and depth (Arifin, 2013). The presentation of the material should also take into account the characteristics of the content. According to Dahar (2011), concrete material is easier to understand because its truth can be verified through direct observation. Conversely, abstract material is more difficult to comprehend because students cannot see it directly. The use of a scientific approach facilitates accommodation of both types of material characteristics. Learning that uses teaching materials and methods suited to students' interests and needs can motivate them to learn, so the use of engaging teaching materials is necessary to encourage students to study effectively (Sanjaya, 2012). Based on the validation results, these four assessment indicators are considered valid with an average score of 0.9.

In the graphic aspect, there are four assessment indicators: the use of font type and size, layout, image display, and cover design. The textbook is clearly readable and visually appealing due to the selection of appropriate font types and sizes. The use of upright, non-cursive fonts is necessary to enhance readability and text clarity (Hojjati & Muniandy, 2014). Each page layout is designed proportionally and attractively to support students' understanding of the material presented. A good layout also facilitates students in studying the book's content (Putri & Astuti, 2014). Furthermore, the textbook includes relevant images and illustrations to support comprehension of the material. Images in the textbook serve to attract attention, clarify concepts, and illustrate facts that may be easily forgotten or overlooked (Nugroho et al., 2014). The cover design is also created with a theme that aligns with the book's content to visually reflect its subject matter (Muktaf, 2016). Thus, the images and illustrations used not only enhance the aesthetic elements but also play a role in motivating students to learn, understand, and remember the material better. According to the validation results, the graphic aspect of the textbook is considered valid with an average score of 0.92.

The validation results of the textbook by the validators were also used to analyze the reliability of the textbook, aiming to measure the level of agreement among the validators. Reliability testing was conducted using the Intraclass Correlation Coefficient (ICC) with the help of IBM SPSS Statistics version 26. The interpretation of ICC results follows these categories: $ICC \geq 0.5$ indicates moderate reliability, $ICC \geq 0.75$ indicates good reliability, and $ICC \geq 0.9$ indicates excellent reliability. The analysis of single measures showed an ICC value of 0.154, which falls into the poor category. Meanwhile, the analysis of average measures yielded an ICC value of 0.686, categorized as moderate. These results indicate a moderate level of agreement among validators in assessing the textbook. After the expert review validation stage, the textbook was further tested through a one-to-one evaluation phase.

After being validated by five validators, the textbook was then tested through a one-to-one evaluation involving four Grade XII high school Biology teachers. This trial aimed to gather responses regarding the intensity of the respondents' behaviors or feelings toward the scientific approach-based textbook that had been developed. The teachers' responses to the textbook covered four main aspects: content, language, presentation, and graphics, which were developed and adapted from Depdiknas (2008) using 21 statements as the assessment instrument. Based on the response test results, the percentage ratings were 93.75% for content, 96.88% for language, 94.53% for presentation, and 97.5% for graphics. The overall average across these four aspects reached 95.66% (Table 6), which falls into the very high category according to the evaluations of the four respondents using a four-category scale (Riduwan, 2015).

The results of the teachers' response test to the developed textbook showed full agreement on two key statements: first, that "the material presented is already aligned with the basic competencies (KD)," and second, that "the developed material is sufficiently broad and deep to achieve the basic competencies for the topic." Both statements received a 100% score with a very high criterion. This indicates that the developed textbook aligns well with the established competency standards, basic competencies, and indicators, thus helping students better understand the material presented (Aisyah et al., 2020). Additionally, the textbook is equipped with images and illustrations that support the explanation of the material, which received a 93.75% response with a very high rating. According to Nasar & Kaleka (2019) conceptual understanding is essential for mastering biology material, so the presentation of material in the textbook must be supported by attractive and relevant images and illustrations to make it easier for students to understand. In terms of language, the use of language in the textbook was rated as easy to understand and clear, with a 93.75% response, also falling under the very high category. This finding aligns with the research of Ismail et al. (2021) which states that language in teaching materials should be simple and clear to be easily understood by students.

After going through the validation and response testing stages, the textbook was revised based on suggestions and comments from the validators and respondents. This revision aimed to improve the product to be better and aligned with the development objectives. One suggestion from the validators during the validation stage concerned the indicator of suitability with students' needs, which had not reached the minimum Aiken's *V* value of 0.87. A Biology Education lecturer from FKIP Untan provided feedback regarding weaknesses in the implementation of the scientific approach in the textbook, where only three stages (3M) appeared to be presented—observing, questioning, and reasoning—while the other two stages, collecting information and communicating, were not explicitly titled. Additionally, there was a correction regarding the questioning aspect, which should emphasize that students ask questions rather than merely answer them. Initially, the grouping of activities in the textbook gave the impression that only three stages (3M) were presented because the other two stages were combined into one activity without

separate titles. Learning with a scientific approach should include all five complete stages (5M), namely observing, questioning, collecting information, associating, and communicating (Pratiwi & Wulandari, 2020). Therefore, revisions were made by adjusting the presentation of activities in the textbook to be clearer and in accordance with the 5M principles.

As found in the interview results during the initial and final analysis stages, several shortcomings were identified in the textbook used by teachers, including: an insufficient or less varied number of evaluation questions (44.4%), limited science activities for students (33.3%), illustrations or images that are less attractive or not clear enough (33.3%), incomplete material coverage (33.3%), language that is quite difficult to understand (22.2%), and the absence of answer keys (22.2%). Specifically for genetics material, additional shortcomings were found, such as illustrations or images that do not support or are unclear (66.6%), explanations that are too brief (55.5%), limited science activities for students (55.5%), language that is still difficult to understand (44.4%), and science activities requiring complete laboratory facilities (33.3%). Overall, the strengths of the textbook developed in this study were able to address the shortcomings felt by teachers at school. Validation and trial results of the development showed that evaluation questions, science activities, more attractive and clear illustrations, more complete material, easy-to-understand language, and the inclusion of answer keys became the main aspects considered in the textbook development. Additionally, the developed textbook can be used for both the 2013 Curriculum and the Merdeka Curriculum. This book is also equipped with QR codes that can be scanned to access video learning links related to the material being studied. This feature facilitates students in understanding the material directly.

By addressing the shortcomings identified during the analysis stage, it is expected that teachers can utilize this textbook more optimally. In addition, the developed textbook is hoped to motivate students in studying the Human Heredity material for Grade XII using a scientific approach. This finding also underscores the importance of developing more innovative textbooks that align with students' needs and curriculum demands. The main implications are the improvement of learning quality, the utilization of technology in education, and the potential increase in students' motivation to learn complex material such as genetics.

CONCLUSION

The development of the textbook on Human Heredity material using a scientific approach has been successfully carried out. This textbook meets the criteria of validity and reliability, as demonstrated by expert validation results covering the aspects of content, language, presentation, and graphics, all categorized as valid. The teachers' response test results show a very high level of acceptance, indicating that this textbook is suitable for further testing to assess its effectiveness as a teaching material. The textbook is designed in accordance with the 2013 Curriculum and the Merdeka Curriculum, equipped with QR code features linking to learning videos, and includes the 5M elements of the scientific approach. This textbook successfully addresses various shortcomings found in previous textbooks, such as incomplete material, lack of evaluation questions, science activities, attractive illustrations, and language clarity. Therefore, this textbook is expected to be an effective learning resource, motivating students in understanding Human Heredity material, as well as supporting independent learning at the senior high school level (SMA/MA).

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