

**DEVELOPMENT OF A MODERN BIOTECHNOLOGY BOOKLET FOR GRADE X SENIOR HIGH SCHOOL BASED ON MANGROVE TISSUE CULTURE RESEARCH**

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**ABSTRACT**

*This study aims to develop a booklet based on research findings on the tissue culture of *Sonneratia alba* as a learning material for the Modern Biotechnology topic in Grade X of Senior High School under the Merdeka Curriculum. The main problem identified in schools is students' low understanding of tissue culture due to limited learning resources and the lack of practical laboratory activities. The booklet was developed using the Research and Development (R&D) model with an ADDIE approach simplified into three stages: Analysis, Design, and Development. Primary data were obtained from research on the effects of NAA and BAP hormone combinations on the *in vitro* germination of *Sonneratia alba*, which served as the basis for the booklet content. Product validation was carried out by media and material experts using a Likert-scale assessment sheet. The media expert validation obtained a percentage of 100% (very valid), while material expert validation reached 94.1% (very valid). The overall average validity of the booklet was 97.05%, which falls into the very valid category. Thus, the *Sonneratia alba* tissue culture booklet is suitable for use as a practical, engaging, and relevant supplementary learning resource to enhance students' understanding of Modern Biotechnology.*

*Keywords: Booklet; Tissue Culture; *Sonneratia alba*; NAA; BAP; Modern Biotechnology.*

## INTRODUCTION

The mangrove ecosystem is a tidal forest found in tropical and subtropical regions that grows in protected coastal areas such as beaches, bays, and lagoons (Mairing & Ariantari, 2022). Indonesia has the largest mangrove ecosystem in the world, contributing 25.79% of the global total (Nabeelah Bibi et al., 2020), yet its area continues to decline due to land conversion for various purposes such as industry, ports, and settlements (Mahadi et al., 2024). The loss of mangroves impacts the ecological functions of coastal areas. One commonly found mangrove genus is *Sonneratia*, particularly *Sonneratia alba*, which can grow up to 15 meters (Pursetyo & Tjahjaningsih, 2013). This species has a high tolerance to salinity and light (Rizki et al., 2023) and possesses pharmacological and economic potential due to its bioactive compounds and the traditional use of its fruit (Ardiansyah et al., 2020).

Its natural regeneration is relatively slow, requiring about 15 weeks to begin germination (Anwar, 2006), and its success is highly influenced by tides and the position where propagules fall (Rizki et al., 2023). Because its germination mechanism is viviparous, growth success is highly dependent on environmental conditions (Darise et al., 2025). Many propagules fail to grow because they fall sideways or are carried away by currents (Dafikri et al., 2022). Environmental factors and human activities further deteriorate regeneration habitats, while this species also competes with other mangrove species (Dewi et al., 2022). These conditions lead to a low success rate of natural regeneration, thus requiring propagation efforts to support conservation.

With technological advancements, *in vitro* culture methods have become an alternative means of modern propagation that provides a sterile and controlled environment, accelerates embryo growth, and enables the production of seedlings in large quantities (Mawaddah et al., 2021). Tissue culture also excels in producing healthy seedlings, maintaining parental traits, being independent of climatic conditions, and enabling the propagation of plants that are difficult to reproduce conventionally (Ziraluo, 2021). The success of tissue culture is strongly influenced by media and plant growth regulators (PGRs). Hormone combinations are more effective than single applications (Nurfauzan et al., 2022). This study used the auxin NAA and the cytokinin BAP. NAA functions in cell elongation, root formation, and tissue differentiation (Lestari et al., 2018). BAP functions in cell division and shoot differentiation (Syahirah et al., 2022). The application of this technique is relevant to the biological technology innovation material for Grade X Senior High School in the Modern Biotechnology topic.

The Merdeka Curriculum for Grade X emphasizes mastery of biological technology innovation concepts, including modern biotechnology at phase E. One important topic is biotechnology products, but pre-survey results indicate that students' understanding of biotechnology concepts, particularly tissue culture, is still low. One major cause is the limited availability of learning resources in schools. Textbooks that are too thick reduce students' interest in reading, making the learning process less interactive and less innovative. This condition requires biology teachers to apply more meaningful, creative, and engaging learning strategies to ensure effective understanding of the material.

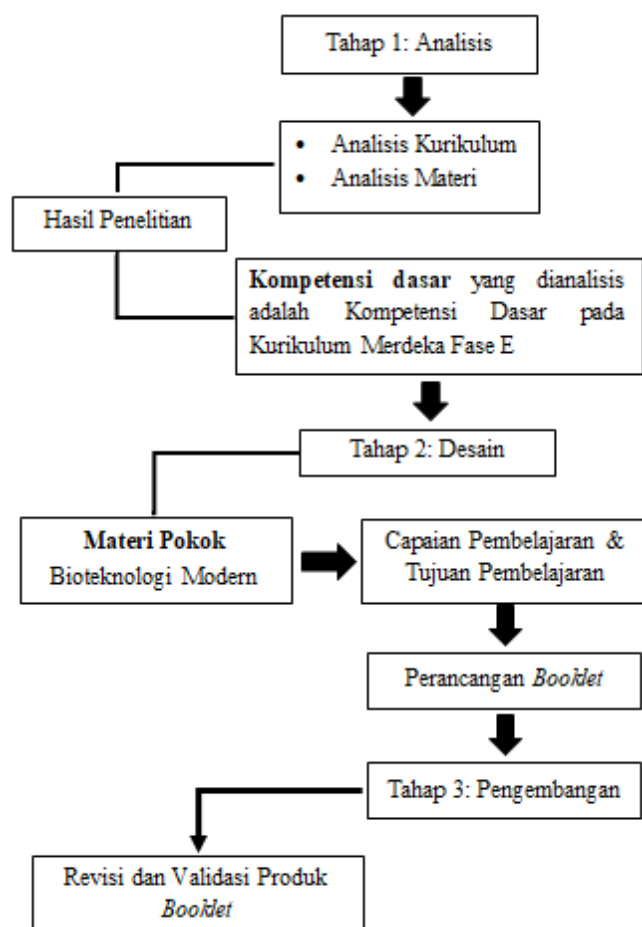
Limited laboratory facilities also pose challenges, especially for tissue culture practicum activities, which are rarely conducted in schools. Therefore, practical and engaging instructional materials are needed to bridge the gap between theory and practice. One relevant alternative is a booklet, a small-sized learning material containing a combination of images and text arranged concisely and aligned with learning competencies. Booklets are considered effective in optimizing cognitive processes because approximately 75–78% of information is processed through visual perception (Imtihana et al., 2018). The use of booklets has also been shown to significantly increase students' learning motivation (Nomleni, 2023). In addition to serving as an attractive visual medium, booklets are easy to understand due to their concise content, focus on a single competency, and portability for student use.

From an instructional design perspective, booklets meet the criteria of good learning materials, including alignment with basic competencies, content relevance, appropriate image selection, attractive layout, and simple language use (Hoiroh & Isnawati, 2020). Physically, a booklet consists of a cover, front section, main content, and end section, designed in half-A4 size for practicality. With these characteristics, booklets offer advantages such as lower production costs, suitability for independent learning, and flexibility in information delivery (Pasaribu et al., 2020). However, booklets also have limitations, such as relatively long production time and effectiveness that depends on students' reading abilities (Nafsiyah, 2020). Nevertheless, their advantages are far more significant for meeting the learning needs of biotechnology in schools.

Based on these issues, developing a booklet derived from tissue culture research provides a relevant solution to increase students' interest, motivation, and understanding of modern biotechnology material within the Merdeka Curriculum, particularly the tissue culture concept that is difficult to practice directly in schools.

## RESEARCH METHODS

The booklet development stage was carried out at the Biology Education Department, Faculty of Teacher Training and Education (FKIP), Universitas Riau, Pekanbaru. This stage was conducted after the experimental tissue culture research had been completed. This research is a development study based on the Research and Development (R&D) approach. In its implementation, the study employed the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). However, in this research, the ADDIE model was simplified into three main stages—Analysis, Design, and Development—focused on producing a learning product that meets instructional needs. The flowchart of the booklet design can be seen as follows:



**Figure 1. Flowchart of the Booklet Design**

After completing the analysis and design stages, the process continued to the development stage. At this stage, the researcher developed the booklet product using a design created through Canva. The booklet was developed to support learning and must undergo a feasibility test to ensure its effectiveness and appropriateness. Validation was carried out using assessment sheets by media experts and material experts to evaluate the alignment of the content with the designed layout. The assessment criteria for each expert are presented in the following table:

**Table 1. Instrument Validation Aspects**

Variable	Aspects Validated
Validity of the Booklet Design Instrument by Media Experts	<ol style="list-style-type: none"> <li>1. Model size, consisting of the suitability of content size with ISO standards and the suitability of size with the content material.</li> <li>2. Content cover design, including the appearance of layout elements on the cover, color of layout elements in the content, font size, and title color on the cover.</li> <li>3. Content cover illustration, including representation of the material/content, expression of object characteristics, and the shape, color, size, and proportion of objects according to reality.</li> <li>4. Content design, consisting of harmonious layout elements, complete layout elements, simple content typography, and content illustrations.</li> </ol>
Validity of the Booklet Design Instrument by Material Experts	<ol style="list-style-type: none"> <li>1. Content feasibility aspect, including the suitability of the material with learning objectives, material accuracy, and accuracy of terminology.</li> <li>2. Language feasibility aspect, including clarity, communicativeness, and appropriateness for students' developmental level.</li> <li>3. Supporting technical feasibility aspect, including supporting techniques for presentation and learning presentation.</li> </ol>

After the validation process was completed, the obtained data were analyzed using descriptive analysis techniques. This technique was carried out by calculating the scores for each predetermined aspect to measure the validity level of the booklet draft. The assessment used a Likert scale, and the score categorization results can be seen in the following table:

**Table 1. Booklet Assessment Score**

Assessment Score	Criteria
4	SS: Strongly Agree
3	S: Agree
2	KS: Less Agree
1	TS: Disagree

The validation results by the validators were calculated using the following formula:

$$M = \frac{\sum Fx}{N}$$

Notes:

M : Average assessment score

Fx : Score obtained

N : Number of validated components

The criteria for decision-making in validating the booklet draft can be seen in the following table:

**Table 2. Validity Criteria**

Percentage Interval	Validity Category
81% - 100%	Very valid
61% - 80%	Valid
41% - 60%	Fairly valid
< 40 %	Not valid

## RESULTS AND DISCUSSION

The research results obtained regarding the effect of NAA and BAP hormone concentrations on the in vitro germination of *Sonneratia alba* can be used as primary data to serve as the basis for designing a booklet as instructional material in Biology learning on the topic of Biological Technology Innovation for Grade X senior high school, specifically the topic of Tissue Culture. The steps in designing the booklet were adapted to the R&D approach using the ADDIE model, which was simplified into the following three stages:

### Analysis

The analysis stage involved conducting a curriculum analysis and a syllabus analysis as required by the Merdeka Curriculum. The curriculum analysis was carried out by examining the curriculum demands in the learning process, including Learning Outcomes (CP) and Learning Objectives (TP), as an initial step to determine the content to be written in the booklet. The initial step of the curriculum analysis was developing the Learning Objectives Flow (ATP), followed by an analysis of the learning materials. The materials to be enriched in the booklet are related to the concept of Biotechnology. The results of the analysis of the relevant basic competencies related to the research findings are presented in Table 4.

**Table 3. Learning Outcomes (CP) and Learning Objectives (TP)**

<b>Learning Outcomes</b>	At the end of Phase E, students are able to create solutions to problems based on local, national, or global issues related to the understanding of biodiversity and its roles, viruses and their roles, <b>biological technology innovations</b> , ecosystem components and interactions among components, as well as environmental changes.	
<b>Learning Objectives</b>	10.3.6	Students are able to explain the principles of plant tissue culture.
	10.3.7	Students are able to explain the advantages and disadvantages of plant tissue culture.
	10.3.8	Students are able to explain the stages of plant tissue culture.

Based on the analysis in Table 4, these Learning Objectives have strong potential to serve as the basis for developing instructional materials because they are aligned with the results of the *Sonneratia alba* tissue culture research and Modern Biotechnology content. The needs analysis indicates that the available materials are still general in nature, and students have never conducted tissue culture practicum activities, resulting in limited insight. Therefore, contextual instructional materials that support deeper conceptual understanding are needed. A booklet is the most appropriate alternative because it is practical, engaging, and able to enhance students' understanding compared to using textbooks alone. The designed booklet is expected to support the learning process and improve students' knowledge and experience regarding tissue culture.

**Design**

The designed booklet layout can be seen in Figure 2.



**Figure 1. Booklet layout**

**Development**

After the booklet was designed using Canva, the completed booklet was then validated by validators. The validation instrument consisted of two types: a media expert validator and a content (subject-matter) expert validator. The aspects validated by the media expert consisted of four indicators for measuring the validity level of the booklet, namely model size, content cover design, content cover illustration, and content layout design. Meanwhile, the aspects validated by the content expert consisted of three indicators: content feasibility, language feasibility, and presentation feasibility. Each validity indicator sheet consisted of different indicators. The validation results are presented in the following discussion:

**Media Expert Validator**

The validation results can be seen in Table 5 below:

**Table 4. Results of Media Expert Validation Assessment of the Booklet**

Aspect	Criteria	Validator Score	Σ Validation Score per Aspect	Percentage	Criteria Model size
Model size	1	4	8	100%	Very Valid
	2	4			
Content cover design (cover)	1	4	16	100%	Very Valid
	2	4			
	3	4			
Content cover illustration	1	4	8	100%	Very Valid
	2	4			
Content layout design	1	4	28	100%	Very Valid
	2	4			
	3	4			

Aspect	Criteria	Validator Score	$\Sigma$ Validation Score per Aspect	Percentage	Criteria Model size
	4	4			
	5	4			
	6	4			
	7	4			
<b>Total</b>				<b>100%</b>	<b>Very Valid</b>

Based on Table 5, the average score of the validation results given by the media expert for the aspects of the booklet is 100%, which falls into the very valid category. This indicates that the developed booklet has met the feasibility criteria and can be used in the learning process.

### Content Expert Validator

The validation results can be seen in Table 6 below:

**Table 5. Results of Content Expert Validation Assessment of the Booklet**

Aspect	Criteria	Validator Score	$\Sigma$ Validation Score per Aspect	Percentage	Criteria
Content feasibility	1	4	22	91,67%	Very Valid
	2	3			
	3	3			
	4	4			
	5	4			
	6	4			
Language feasibility	1	3	29	90,63%	Very Valid
	2	3			
	3	4			
	4	4			
	5	4			
	6	4			
	7	3			
	8	4			
Presentation feasibility	1	4	12	100%	Very Valid
	2	4			
	3	4			
<b>Total</b>				<b>94,1%</b>	<b>Very Valid</b>

Based on Table 6, the average score of the validation results given by the content expert for the aspects of the booklet is 94.1%, which falls into the very valid category. This indicates that the developed booklet has met the feasibility criteria and can be used in the learning process.

### Average Results of Media Expert and Content Expert Validators

The average results of the booklet validation conducted by the content expert and the media expert can be seen in Table 7 below:

**Table 6. Average Results of Booklet Validation**

Validator	Average Percentage	Description
Media Expert Validator	100%	Very Valid
Content Expert Validator	94,1%	Very Valid
<b>Total</b>	<b>97,05%</b>	<b>Very Valid</b>

Based on Table 7, the average validation score of the booklet from both the media expert and the content expert on Modern Biotechnology material is 97.05%, which falls into the very valid category. This indicates that the designed booklet meets the criteria for good instructional media in Modern Biotechnology.

## CONCLUSIONS

The validity results of the *Sonneratia alba* Tissue Culture Booklet obtained an average validity score of 97.05%, indicating that this booklet design falls into the very valid category and can be used as a learning resource for Modern Biotechnology material for Grade X senior high school.

## ACKNOWLEDGEMENTS

The authors would like to express their gratitude to all colleagues for the support and opportunities provided, which enabled this research to be conducted successfully. Appreciation is also extended to

all parties at the University of Riau who assisted in the implementation of the research and the preparation of this manuscript, both directly and indirectly.

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