

## DEVELOPMENT OF INTERACTIVE FLIPBOOK MEDIA INTEGRATED WITH ANIMATION TECHNOLOGY TO IMPROVE STUDENTS' LEARNING MOTIVATION IN BIOTECHNOLOGY

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**ABSTRACT:** This study aimed to develop an interactive flipbook learning media integrated with animation technology on the topic of Innovation in Biological Technology for Grade X students at SMA Negeri 1 Medan, and to evaluate its feasibility, practicality, and effectiveness in improving students' learning motivation. The research employed the 4D development model (Define, Design, Develop, Disseminate) proposed by Thiagarajan. The research subjects consisted of 35 Grade X students, with 5 students participating in the individual trial and 30 students in the small group trial. Instruments used included expert validation sheets, student and teacher response questionnaires, and a learning motivation observation sheet based on the ARCS model (Attention, Relevance, Confidence, Satisfaction). Data were analyzed using percentage scores on a Likert scale and Normalized Gain (N-Gain) calculations. The results showed that the developed media achieved highly feasible validation scores from material (88,5%), learning (93,2%), and media (95,5%) experts. The biology teacher's response (88,3%) and student responses in both the small-group (90,5%) and large-group (90,5%) trials were likewise categorized as highly feasible. Students' learning motivation improved significantly, as indicated by a high N-Gain score of 0,81. The mean motivation score increased by 59,5% from the pretest to the posttest. These findings indicate that the developed interactive flipbook media is feasible, practical, and effective for improving students' learning motivation in biotechnology learning.

**Keywords:** Animation Technology, ARCS Model, Biotechnology, Interactive Flipbook, Learning Motivation.

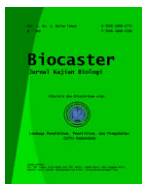
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## INTRODUCTION

Education in the 21st century demands the mastery of critical thinking, creativity, communication, and collaboration skills as fundamental student competencies. In the Indonesian Merdeka Curriculum, biotechnology content is introduced at Grade X under the topic of Innovation in Biological Technology, emphasizing conceptual understanding, process literacy, and real-life applications (Nubuwwah et al., 2025). Despite curriculum mandates, classroom practice at many schools including SMA Negeri 1 Medan still relies on conventional, non-interactive media such as printed textbooks and static PowerPoint slides. Observations and

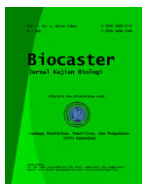


teacher interviews at SMA Negeri 1 Medan confirmed that these approaches fail to fully support student engagement, particularly for abstract and process-intensive biotechnology topics such as genetic engineering, tissue culture, and animal cloning. A pre-research questionnaire on learning motivation and media needs was administered to the 35 Grade X (class X-12) students of SMA Negeri 1 Medan prior to product development. The instrument addressed students' classroom engagement, their perceived difficulty with abstract, process-based biotechnology topics (e.g., tissue culture, cloning, genetic engineering), and their preference for more interactive, visually supported learning media. Results indicated reduced engagement and comprehension difficulty when instruction relied mainly on content-focused explanation with limited visual and interactive support, corroborating an independent teacher interview that similarly identified low learning motivation in this material.

Learning media fundamentally functions to clarify messages, capture student attention, and overcome sensory and experiential limitations (Nurrita, 2018; Pramana et al., 2022). Modern digital media can integrate text, images, animations, videos, and audio in one platform, enabling more comprehensive information delivery (Romanenko & Ryago, 2024). The selection of appropriate media is especially critical for complex or abstract subjects, such as biotechnology, which require process visualization. When media lacks interactivity and contextual relevance, students' motivation to learn tends to decline (Mayer, 2021). Animations, in particular, have been shown to significantly improve learning motivation, conceptual comprehension, and reduce student boredom (Syahfitri & Safitri, 2024; Wijayanti & Isnawati, 2023). Nubuwwah et al. (2025) demonstrated that animated videos have a significant impact on improving learning outcomes in Biotechnology.

Interactive flipbooks represent a promising solution: digital books that present text, images, videos, and animations in an integrated, page-turning digital book format accessible through smartphones and laptops. Research by Wijayanti & Isnawati (2023) demonstrated that flipbook-based media increased student learning motivation from 64,44% to 94,44% in biology learning. Similarly, Firmansyah & Munawwaroh (2023) reported that flipbook media for circulatory system biology materials achieved feasibility scores of 94,26% from students. Awwaliyah et al. (2022) found that flipbook-based e-modules effectively increased junior high school students' learning motivation in science.

Despite this growing body of evidence, the integration of animation technology within flipbooks specifically for biotechnology topics under the Merdeka Curriculum evaluated using the ARCS motivational framework, has not been systematically explored. This gap constitutes the research novelty of the present study for several reasons. First, previous flipbook-based media (Awwaliyah et al., 2022; Wijayanti & Isnawati, 2023) did not incorporate embedded animation to visualize dynamic biological processes. Second, prior studies in this domain more often evaluated learning outcomes or general practicality rather than learning motivation specifically (Firmansyah & Munawwaroh, 2023; Widiastuti, 2021). Third, biotechnology remains comparatively underexplored in flipbook/animation media research relative to topics such as the nervous or circulatory systems. Fourth, despite its theoretical relevance, the ARCS motivational framework has rarely been



operationalized in the design and evaluation of biotechnology learning media. The present study addresses these four gaps simultaneously.

To guide motivational design, this study drew on the ARCS model developed by Keller (Fang et al., 2024), which encompasses four components: Attention (arousing and maintaining student interest), Relevance (relating content to student needs and experiences), Confidence (supporting students' belief in their own learning capacity), and Satisfaction (reinforcing achievement through positive feedback). The ARCS framework served as a pedagogical basis to ensure that the developed flipbook was not merely informative but also genuinely motivating. Combined with the 4D development model (Define, Design, Develop, Disseminate) proposed by Thiagarajan (Susanto et al., 2022), the study aimed to produce a systematically validated, animation-integrated interactive flipbook that addresses the identified gap in biotechnology learning media.

Therefore, this study aimed to: 1) describe the development process of animation-integrated interactive flipbook learning media on Innovation in Biological Technology for Grade X students at SMA Negeri 1 Medan; 2) determine the feasibility of the developed media based on material, learning, and media expert evaluations as well as teacher and student responses; and 3) identify the improvement in students' learning motivation after using the developed media.

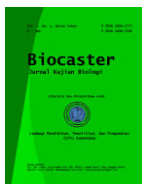
## METHODS

This study used a Research and Development (R&D) approach employing the 4D model (Define, Design, Develop, Disseminate) developed by Thiagarajan et al. (1974), conducted from January to April 2026 at SMA Negeri 1 Medan. To evaluate the effect of the developed media on learning motivation, a one-group pretest–posttest design ( $O_1 \times O_2$ ) was used, where  $O_1$  denotes the pretest,  $X$  the treatment (the developed media), and  $O_2$  the posttest.

This study also involving 35 Grade X students from a single class at SMA Negeri 1 Medan, selected through purposive sampling on the recommendation of the biology teacher because the class had already covered the relevant biotechnology topic and was available for the full trial period. The research object was an animation-integrated interactive flipbook on Biotechnology Innovation, validated by one material expert (biotechnology content specialist), one learning expert (a lecturer with expertise in biology education), and one media/design expert, and tested in two sequential stages: a small-group trial (5 students) assessing usability, clarity, and initial practicality, followed by a large-group trial (30 students) assessing practicality and effectiveness in improving learning motivation. Data Analysis. Data were collected using expert validation sheets, students' response questionnaires, and ARCS-based learning motivation questionnaires. The expert validation and students' response data were analyzed using the feasibility percentage formula:

$$\text{Feasibility (\%)} = \frac{\text{Score Obtained}}{\text{Maximum Score}} \times 100\%$$

The feasibility results were interpreted based on the following criteria: Highly Feasible (85–100%), Suitable (70–84%), Fairly Acceptable (55–69%), and Uniform Resource Locator: <https://e-journal.lp3kamandanu.com/index.php/biocaster>



Not Suitable (0–54%) (Sugiyono, 2017; Winarsunu, 2017). Students' learning motivation improvement was analyzed using the Normalized Gain (N-Gain) formula:

$$N\text{-Gain} = \frac{\text{Posttest} - \text{Pretest}}{\text{Maximum Score} - \text{Pretest}}$$

(Source: Hake, 1998).

The N-Gain values were interpreted as High ( $g > 0.7$ ), Moderate ( $0.3 \leq g \leq 0.7$ ), and Low ( $g < 0.3$ ). All descriptive statistical analyses, including feasibility percentage calculations and N-Gain analysis, were performed using Microsoft Excel 2021.

## RESULTS AND DISCUSSION

### Define Stage

The Define stage identified several instructional needs related to modern biotechnology learning for Grade X students. The needs analysis, conducted through teacher interviews, classroom observations, and curriculum review, revealed that learning activities were predominantly based on textbooks, printed worksheets, and PowerPoint presentations, resulting in low student engagement and limited learning motivation. Student analysis further indicated that although most students were familiar with smartphones and digital platforms, they had limited access to digital biology learning media capable of effectively visualizing process-based concepts.. In addition, concept analysis produced a sequenced content structure: 1) definition of biotechnology; 2) types of biotechnology; 3) modern biotechnology; 4) plant tissue culture; 5) animal cloning; 6) genetic engineering; 7) applications of genetic engineering; and 8) positive and negative impacts of modern biotechnology. These concepts were aligned with the Learning Objective Flow (ATP) for Grade X Biology (Phase E) of the *Merdeka* Curriculum. Overall, the findings of the Define stage indicated the need for an interactive digital learning medium capable of integrating visual and verbal representations to facilitate students' understanding of abstract biotechnology concepts, consistent with the multimedia learning principles proposed by Mayer (2021).

### Design Stage

The Design stage resulted in the development blueprint of an animation-integrated interactive flipbook based on the instructional needs identified during the Define stage. The product design incorporated text, images, animations, and interactive navigation features within a single platform accessible via smartphones and laptops.. The media format was structured with the following components: 1) Cover page with title and developer identity; 2) Instructions for using the media; 3) Learning outcomes and objectives; 4) Concept map of modern biotechnology; 5) Learning materials with embedded text, images, and animations; 6) Supporting animation videos for visualizing abstract processes; 7) Interactive evaluation (Quizizz); and 8) References. In addition, an ARCS-based learning motivation questionnaire employing a four-point Likert scale was prepared for pretest and posttest administration to evaluate changes in students' learning motivation. These

outputs served as the initial prototype for subsequent expert validation and field testing during the develop stage.



Figure 1. Initial Design.

## Develop Stage

### Expert Validation Results

The developed interactive flipbook was validated by three expert groups. Each expert group provided feedback and assessments to evaluate the flipbook's material, learning, and media for learning. Results are presented in Table 1.

Table 1. Summary of Expert Validation Results.

| No. | Validation Type | Total Score | Maximum Score | Percentage (%) | Criteria        |
|-----|-----------------|-------------|---------------|----------------|-----------------|
| 1   | Material Expert | 46          | 52            | 88,5%          | Highly Feasible |
| 2   | Learning Expert | 41          | 44            | 93,2%          | Highly Feasible |
| 3   | Media Expert    | 63          | 66            | 95,5%          | Highly Feasible |

As shown in Table 1, all three expert domains rated the media Highly Feasible (88,5–95,5%). Content-related revisions focused on adding explicit learning-outcome statements and contextual real-life examples (material expert); instructional revisions addressed literature citations, image sourcing, and quiz-objective alignment (learning expert); and design revisions covered cover layout, font standardization, and navigation functionality (media expert). All recommended revisions were incorporated prior to field testing. These validation scores are consistent with the findings of Ramadhan et al. (2024), who reported that Powtoon-based interactive animation media for biotechnology received media expert scores of 93,75% and material expert scores of 84,38%. Similarly, Firmansyah & Munawwaroh (2023) documented that flipbook media for biology circulatory system content received expert validation scores exceeding 78%, confirming the broader pattern that well-designed digital flipbooks consistently meet high feasibility standards across biology topics.

### Teacher and Student Response Results

Following validation, the media was evaluated through teacher and student trials. Results are presented in Table 2.

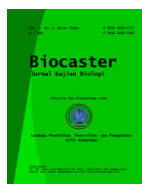


**Table 2. Summary of Teacher and Student Response Results.**

| No.     | Assessment Component | Teacher Response (%) | Small Group Trial (%) | Large Group Trial (%) | Criteria        |
|---------|----------------------|----------------------|-----------------------|-----------------------|-----------------|
| 1       | Display              | 87,5                 | 91,6                  | 93,6                  | Highly Feasible |
| 2       | Material             | 87,5                 | 90,0                  | 90,5                  | Highly Feasible |
| 3       | Interactivity        | 93,8                 | 88,3                  | 88,8                  | Highly Feasible |
| 4       | Media Benefits       | 83,3                 | 92,0                  | 89,1                  | Highly Feasible |
| Average |                      | 88,3                 | 90,5                  | 90,5                  | Highly Feasible |

The biology teacher's response yielded an overall score of 88,3% (Highly Feasible). The teacher noted that the developed flipbook was attractive, interactive, and effective in supporting the explanation of abstract biotechnology concepts while increasing students' classroom participation. The similarity between the small-group (90,47%) and large-group (90,54%) trial averages suggests consistent perceived practicality of the media across different group sizes. The findings of this study are consistent with those reported by Budiarto & Sulistiyo (2021), who found that interactive flipbook media positively influence students' learning outcomes and practical learning skills. Similar results were observed in the present study, where the animation-integrated interactive flipbook achieved a high display aspect score of 93,6% in the large-group trial. This finding indicates that integrating attractive visual elements and interactive features can enhance students' interest and engagement during the learning process, particularly when learning abstract biotechnology concepts. The high level of students' positive responses further suggests that the developed media was able to facilitate a more engaging learning experience, thereby supporting students' learning motivation.

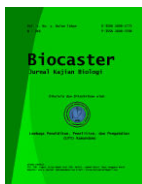
#### ***Improvement of Students' Learning Motivation***

The effectiveness of the developed media was assessed through the improvement of students' learning motivation measured using the ARCS-based observation sheet. Pretest and posttest data were analyzed using the N-Gain formula. Results are presented in Table 3.

**Table 3. N-Gain Calculation of Learning Motivation.**

| No.      | Description               | Score |
|----------|---------------------------|-------|
| 1        | Total Pretest Score       | 37    |
| 2        | Total Posttest Score      | 59    |
| 3        | Percentage of Improvement | 59,5% |
| 4        | Maximum Score             | 64    |
| 5        | N-Gain Score              | 0,81  |
| Category |                           | High  |

The N-Gain score of 0,81 falls within the high category ( $g > 0,7$ ), indicating a 59,5% improvement in students' learning motivation from pretest (score: 37) to posttest (score: 59) out of a maximum score of 64. This significant improvement can be attributed to the four ARCS components embedded in the media design. The Attention component was addressed through visually engaging animations, dynamic transitions, and interactive navigation that consistently captured students' focus during the learning process. The Relevance component was fulfilled by contextualizing biotechnology concepts with real-world applications such as



COVID-19 recombinant vaccines, transgenic crops, and stem cell therapy that connected abstract material to students' everyday lives. The Confidence component was supported by a systematic and scaffolded content structure, enabling students to progress through material at their own pace and build understanding incrementally. The Satisfaction component was reinforced through interactive Quizizz evaluation, which provided immediate feedback and a sense of accomplishment upon task completion.

These findings align with prior research reporting similarly high motivation gains from animation- or flipbook-based media (Ramadhan et al., 2024; Widiastuti, 2021; Wijayanti & Isnawati, 2023). The similarity is plausibly explained by a shared mechanism: all these media, including the present one, operationalize the ARCS components through visual attention-capturing elements, real-world relevance, scaffolded content, and immediate feedback, consistent with Mayer's (2021) dual-channel processing theory. Where studies differ is in magnitude and content domain for instance, Wijayanti & Isnawati (2023) achieved a larger raw percentage gain (64,44% to 94,44%) in nervous-system content using a different measurement scale, whereas the present study is, to our knowledge, the first to combine embedded animation, an interactive flipbook, and the ARCS framework specifically for biotechnology content, which is the study's principal scientific contribution.

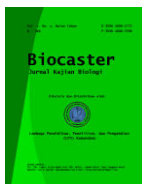
For teachers, these findings suggest that pairing animation with structured motivational design (rather than either element alone) is a viable strategy for abstract biology topics; for schools, the flipbook's low-cost, device-agnostic distribution model offers a scalable alternative to commercial platforms with paid-feature restrictions noted in comparable studies (Ramadhan et al., 2024). A methodological limitation should also be acknowledged: the one-group pretest–posttest design, absence of a control group, and single-class, single-school sample ( $N = 35$ ) constrain causal attribution and generalizability, and future replication across multiple classes or schools with a comparison group is recommended.

### **Disseminate Stage**

The dissemination stage was carried out after the animation-assisted interactive flipbook learning media had been declared feasible based on the results of expert validation and development trials. At this stage, the developed media was distributed on a limited basis to teachers and students at SMA Negeri 1 Medan. The dissemination was conducted in the form of a digital file that could be accessed through devices such as smartphones and laptops. This learning media can be used by teachers as an alternative teaching material in the biology learning process, especially on modern biotechnology material, as well as by students as an independent learning resource that can be accessed anytime and anywhere.

### **CONCLUSIONS**

This study successfully developed an animation-integrated interactive flipbook learning media for the Innovation in Biological Technology topic using the 4D development model. The developed media was declared highly feasible across all three expert-validation domains and highly practical according to both teacher and student responses (see Table 1 and Table 2 for full figures), confirming



its suitability for classroom use. The developed media effectively improved students' learning motivation, as evidenced by an N-Gain score of 0,81 (High category) with a percentage improvement of 59,5%. These findings demonstrate that the animation-integrated interactive flipbook shows strong potential as a feasible, practical, and effective learning medium for biotechnology instruction, particularly for complex and abstract concepts under the Merdeka Curriculum.

## RECOMMENDATION

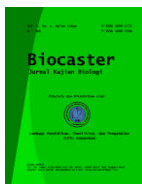
Based on the results of this study, the following suggestions are proposed. First, the interactive flipbook media can be further developed for other biotechnology subtopics or different biology materials by teachers or future researchers to broaden its applicability in the learning process. Second, the media development process should be carried out systematically, beginning with scenario preparation, storyboard creation, collection of images and supporting animations, and determination of the material presentation flow, to facilitate efficient product creation. Third, the integration of the ARCS model in the design of digital learning media is recommended as a systematic approach for building and sustaining student motivation across diverse biology topics.

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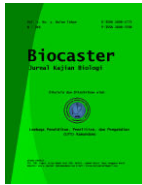
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