

# Personalization of Academic Interests: The Impact of Differentiated Smart Flipbook on Motivation and Concept Mastery in Reproductive System Learning

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**ABSTRACT.** Learning the human reproductive system in secondary schools is often hampered by the abstraction of complex biological concepts and by psychological barriers that conventional methods do not accommodate. This study aims to test the effectiveness of Differentiated Smart Flipbook media integrated with an AI Chatbot in improving concept mastery and motivation, and to investigate its inclusiveness for students with different academic interest profiles, namely Science and Sports. Using a Quasi-Experiment design with a Nonequivalent Control Group Design pattern, the study involved 113 ninth-grade students of MTs Negeri 3 Grobogan. The results of statistical tests showed that the experimental class achieved an N-Gain increase of 0.70 (high category), significantly higher than the control class, which achieved only 0.21. The most crucial finding was that this media successfully minimized the achievement gap; students interested in Sports accelerated their learning with an N-Gain of 0.67, closely following Science students (0.72). In-depth analysis reveals the operation of the Dual Coding mechanism: the AI Chatbot feature effectively facilitates Science students' analytical skills (C4) through in-depth inquiry. At the same time, 3D visualization strengthens Sports students' application skills (C3) through physical contextualization. It is concluded that AI-based content personalization effectively reduces cognitive load and significantly increases motivation, especially in the Relevance and Confidence aspects, making this medium an adaptive solution for realizing inclusive and equitable biology learning.

**Keywords:** *Differentiated Smart Flipbook, Differentiated Learning, Reproductive System, AI Chatbot, Learning Outcomes.*

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## INTRODUCTION

Biology learning on Human Reproductive System material presents complex pedagogical challenges due to its abstract nature and frequent perception as a social taboo. Student difficulties in visualizing microscopic processes such as gametogenesis often trigger fatal misconceptions that hinder the understanding of basic concepts (Wahyuni et al., 2019). These barriers are not only cognitive but also psychological, where the use of conventional media or physical props like the Surprise Box is often insufficient to overcome students' awkwardness in discussion (Rukman, 2024). This rigid classroom situation ultimately creates a transactional distance between teachers and students, even though this material plays a vital role in adolescent health literacy.

Diagnostic analysis at MTs Negeri 3 Grobogan reveals a deeper root cause, namely a sharp gap between teaching methods and student learning profiles. Preliminary observation data validated

by a quantitative research approach show significant modality disparities: the Science Excellence Class is dominated (85%) by visual learning styles, while the Special Sports Class shows a strong kinesthetic preference (Sugiyono, 2021). Realities of curriculum implementation in the field, however, often ignore this heterogeneity, so that students' academic potential is not optimally accommodated (Sitorus, 2025). As a result of this pedagogical mismatch, the average student learning result remains at 50, far below the Minimum Completeness Criteria (KKM).

Modern educational principles emphasize the need for differentiated instruction to respond to the diversity of student readiness, interests, and learning profiles. Tomlinson (2001) asserts that effective teaching must begin with mapping student needs, not just one-way material delivery. The relevance of this theory is strengthening within the context of the Merdeka Curriculum, which requires teachers to design learning that is flexible and adaptive to the unique characteristics of each learner (Sitorus, 2025). Technical challenges in manually providing different materials for Science and Sports classes simultaneously, however, often become a distinct cognitive burden for educators.

Development of current digital teaching media, such as E-Modules based on *Flip PDF Corporate*, generally remains static and linear (Sugianto et al., 2023). Limitations of these conventional media fail to facilitate the immersive learning experience students need. The solution offered in this study presents technopedagogical novelty through the integration of QR Code features that present three-dimensional (3D) object visualizations, allowing students to observe anatomical structures realistically from various viewpoints. Furthermore, this media is equipped with a Chatbot feature to facilitate in depth inquiry while providing a psychologically safe environment for asking sensitive topics anonymously. These innovative features are designed to surpass the limitations of previous physical and digital media that have not been able to provide intelligent interactivity and spatial visualization simultaneously (Rukman, 2024).

This study aims to test the effectiveness of the "Differentiated Smart Flipbook" which has been reinforced with these novelty features. The main focus of the study is to prove the hypothesis that the integration of 3D visualization and AI intelligent assistance can significantly reduce student misconceptions (Wahyuni et al., 2019). Furthermore, this research specifically highlights the aspect of media inclusivity in bridging the academic achievement gap between visual students in the Science Class and kinesthetic students in the Sports Class. This empirical evidence is expected to validate the role of adaptive technology as an instrument for equalizing learning quality amidst the diversity of student interests.

## METHOD

This study applies the Research and Development (R&D) approach by adapting the ADDIE ( Analysis, Design, Development, Implementation, Evaluation ) development model as proposed by Branch (2009). Although the development procedure is carried out in its entirety through the five stages, in the context of this article, the focus of the discussion is emphasized on the Implementation and Evaluation stages. The aim is to present empirical evidence regarding the effectiveness of the Differentiated Smart Flipbook product on improving the dependent variables, namely student concept mastery and learning motivation.

The field trial design used a Quasi-Experimental Design with a Nonequivalent Control Group Design pattern (Sugiyono, 2021). This design was chosen because the research subjects were students in study groups that had formed naturally at the school, so that total randomization ( random assignment ) was not possible.

The research was conducted at MTs Negeri 3 Grobogan in the odd semester of the 2025/2026 academic year . The research subjects included all ninth grade students, with sampling using a purposive sampling technique . The selected samples were grouped into two groups, namely

the experimental class (n=58) which was taught using Differentiated Smart Flipbook and the control class (n=55) which used conventional teaching materials.

The next step is to analyze the effectiveness of the media based on the characteristics of the subjects ( Funds of Knowledge ), the experimental group is mapped into two different background clusters, namely the sports interest class and the science interest class. This interest class is a study group policy at MT's Negeri 3 Grobogan to create a conducive learning environment for the development of individual potential.

A fundamental prerequisite to ensure the internal validity of the research before entering the field experiment stage, the Differentiated Smart Flipbook media prototype has gone through a rigorous expert judgment process . This evaluation involved a panel of material experts and media experts who were selectively selected based on academic credibility and relevant experience . The quantitative data from the expert assessments were then analyzed using the Aiken's V content validity coefficient formula as explained by (Retnawati, 2016). Based on the calculation results, this teaching media obtained a validity index with the "Valid" category, which empirically confirmed that the material construction and differentiation features therein had met the theoretical and practical feasibility standards for implementation as an intervention instrument in learning .

**Table 1** Media Validation Results

Validation	Aiken's Index	Information
Material	0.91	Valid
Media	0.97	Valid

Validation results content material recorded an Aiken's V index of 0.91. This figure not only guarantees the epistemological validity of the reproductive system concept, but also ensures that the depth of the material is aligned with the curriculum demands and is free from potential misconceptions. Parallel to these findings, the validation of the media construct recorded a near-perfect achievement with an index of 0.97. This achievement is a strong indicator that the media's technopedagogical architecture, especially the content differentiation feature and AI Chatbot integration, has functioned optimally, responsively, and is user-friendly. The accumulated assessment of these two aspects confirms that Smart Flipbook has met the strong theoretical feasibility requirements to proceed to the empirical effectiveness testing stage in the field.

Test recorded an impressive score of 90.55%, categorized as very practical. This figure confirms that the media not only boasts high visual readability but also supports intuitive navigation that offers significant ease of use for students, minimizing technical challenges during learning.

**Table 2** Media Practicality

Indicator	Percentage Value	Category
Material	88.44	Very Practical
Graphic	90.32	Very Practical
Interactivity	88.71	Very Practical
Accessibility	89.52	Very Practical
Motivation to learn	86.29	Very Practical
Concept Mastery	88.71	Very Practical
<b>Average</b>	<b>90.55</b>	<b>Very Practical</b>

Next step stage testing effectiveness use a series comprehensive assessment. Instrument primary data collection in the form of test mastery draft shaped Multiple Choice ( Multiple Choice ) consisting of 25 items which include: realm cognitive C1 to C4. Compilation grains referring to the Revised Bloom's Taxonomy (C1–C4) to be able to measure understanding, application, and

analysis No just memorization. Instrument This has fulfil standard quality psychometrics based on trials empirical analysis use JASP software.

Evaluation psychometrics done For ensure quality instrument test mastery concept. Validity grains tested use technique item-rest correlation , temporary internal consistency is measured use Cronbach's Alpha. Based on standard applicable psychometrics, (Pallant, 2020) coefficient acceptance limit ( cut-off ) correlation set of 0.30. Consequently , the item questions that have mark correlation below the threshold stated fall and be eliminated from analysis For guard Power different instrument. After the process of eliminating invalid items, the reliability analysis on the final instrument produced a Cronbach's Alpha coefficient of 0.856.

**Table 3** Reliability Test Results

Instrument Test		Question Items
Validity	Valid	1,2,3,4,5,6,7, 8,9,10,11,14,17,18,19,20,21, 22,23,15
	Invalid	12,13,15,16,24
Reliability	Cronbach Alpha	0.856
	Criteria	Very strong reliability

The achievement of the reliability coefficient places the test instrument in the "very strong" category according to the classification (Zanzam & Marsinah, 2021). Psychometrically, this high figure indicates that the items compiled have a high level of internal consistency and precise stability. This means that this instrument is able to provide relatively consistent measurement results even when tested at different times, and has high resistance to distortion due to measurement error. Thus, this instrument is declared worthy and can be trusted to accurately capture students' cognitive competencies.

Learning motivation data were collected through an ARCS-based questionnaire (Keller, 2009), covering the dimensions of Attention, Relevance, Confidence, and Satisfaction. The quality of this instrument was confirmed through expert validation using percentage score analysis. The analysis results showed that this instrument met the "Very Adequate" criteria with a score of 89.63%, thus the validity of the motivation data obtained in this study can be accounted for.

**Table 4** Validation Results Instrument Questionnaire

Aspect	Percentage(%)	Information
Content Suitability	90.00	Very Worthy
ARCS Component Coverage	93.33	Very Worthy
Editorial Clarity	83.33	Very Worthy
Language Compatibility	91.11	Very Worthy
Format Compliance and Filling Instructions	86.67	Very Worthy
Readability and Display	93.33	Very Worthy
Average	89.63	Very worthy

Data analysis was carried out through procedure statistics quantitative systematic inferential For answer hypothesis research. Before done testing hypothesis, raw data moreover formerly verified through prerequisite tests analysis, including normality tests use technique Kolmogorov-Smirnov and homogeneity test variance use Levene's Test For ensure data meets assumptions parametric . Furthermore , the effectiveness improvement results Study analyzed use index Normalized Gain (N-Gain) refers to the criteria.

Hake (1999), which aims to eliminate bias in the initial score ( pretest ) in measuring competency improvement. The significance of the difference in effectiveness between the experimental and control classes was then tested using the Independent Sample t-test at a

significance level of 5% ( $\alpha = 0.05$ ). In addition, further comparative analysis was also carried out specifically on the experimental group to dissect the disparity in achievement between the clusters of students interested in science and sports, in order to evaluate the inclusiveness of the media towards different interest profiles.

## RESULT AND DISCUSSION

### Result

The validity of the statistical analysis in this study began with a rigorous examination of the data prerequisite assumptions to ensure the reliability of the hypothesis testing. Normality testing using the Kolmogorov-Smirnov method on the posttest data of both groups yielded a significance value above the 0.05 threshold ( $p > 0.05$ ), indicating that the data distribution follows a normal curve. The consistency of variance between groups was also confirmed by Levene's Test of homogeneity, which met statistical requirements, allowing the parametric analysis to proceed without distribution bias. Fulfillment of these basic assumptions provides a strong foundation that subsequent data differences are purely due to the treatment intervention, not statistical distortion.

**Table 5** Summary of Data Analysis Prerequisite Tests

Data Variables	Normality Test (Kolmogorov-Smirnov)	Homogeneity Test (Levene's Test)	Statistical Conclusion
Experiment Posttest	0.104	0.760	Normal, Homogen
Posttest Control	0.577	0.760	Normal, Homogen

A comparative analysis of learning outcomes revealed substantial performance disparities between the class using Differentiated Smart Flipbook and the conventional class. Initial data showed that both groups began learning with relatively equal pretest scores (38.97 versus 36.00), but the media intervention provided drastically different accelerations in understanding at the end of the learning. The experimental group successfully recorded an increase in concept mastery (N-Gain) of 0.70, which is in the high category, far exceeding the control group which was stuck at an N-Gain of 0.21, or the low category. The Independent Sample t-test with a significance value of  $p < 0.001$  further confirms the empirical evidence that adaptive media integration has a determinant impact on the surge in students' cognitive competence.

**Table 6** N-Gain Improvement Between Experimental and Control Classes

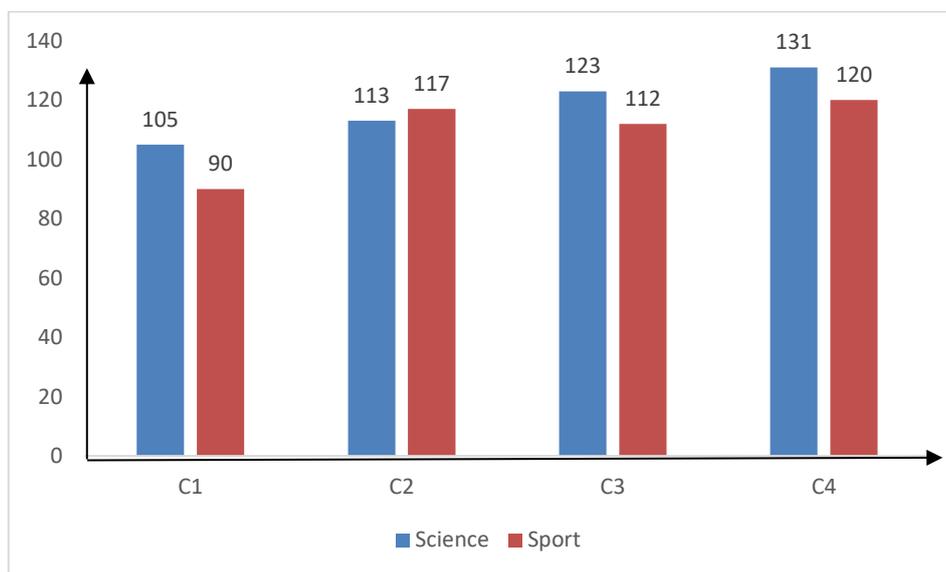
Class	Pretest Average	Posttest Mean	N-Gain	Category
Experiment	38.97	78.53	0.70	Tall
Control	36.00	49.82	0.21	Low

The superiority of this differentiation-based method is more evident when the data is broken down based on student interest profiles, particularly between Science and Sports majors. Initial conditions revealed a gap in academic competency, with Science majors dominating with a pretest average of 41.90 compared to Sports majors who only achieved 36.03. Personalized learning interventions were able to bridge this gap, as evidenced by the learning acceleration of Sports majors who recorded an N-Gain of 0.67, closely following the achievement of Science majors at 0.72. This convergence of final results indicates that the developed media successfully facilitated equal distribution of learning quality, enabling students with non-academic backgrounds to effectively catch up.

**Table 7** Academic Achievements Based on Interest Class

Class	Pretest Average	Posttest Mean	N-Gain	Category
Science	41.90	81.38	0.72	Tall
Sport	36.03	75.69	0.67	Currently

The equality of the final results was apparently achieved through unique and different cognitive mechanisms in each interest group. The distribution pattern of thinking skills shows that although both groups mastered the basic levels of Remembering (C1) and Understanding (C2), strategy divergence occurred at the higher-order thinking level. Students interested in Science tended to maximize performance in the Analyzing (C4) domain through intense inquiry interactions with the AI Chatbot feature, while students interested in Sports showed dominance in the Applying (C3) domain thanks to the help of concrete 3D visualizations. This phenomenon proves that media facilitates two different cognitive trajectories verbal-analytical and visual-kinesthetic to lead students to the same goal of understanding concepts.



**Figure 1** Cognitive Dominance Pattern of Science and Sports Students

The impact of the cognitive intervention was directly proportional to the students' affective responses recorded through the ARCS motivational instrument. The motivational profile showed consistently high scores across the four main dimensions, but with specific emphases aligned with the students' interests. The Relevance aspect experienced the sharpest spike in the Sports students, who felt the material became more connected to their physical activities, while the Confidence aspect dominated in the Science students due to the instant validation of understanding from the system. The high overall Satisfaction score concluded this series of findings, confirming that adaptive learning environments not only improve test scores but also create deep learning satisfaction for all students.

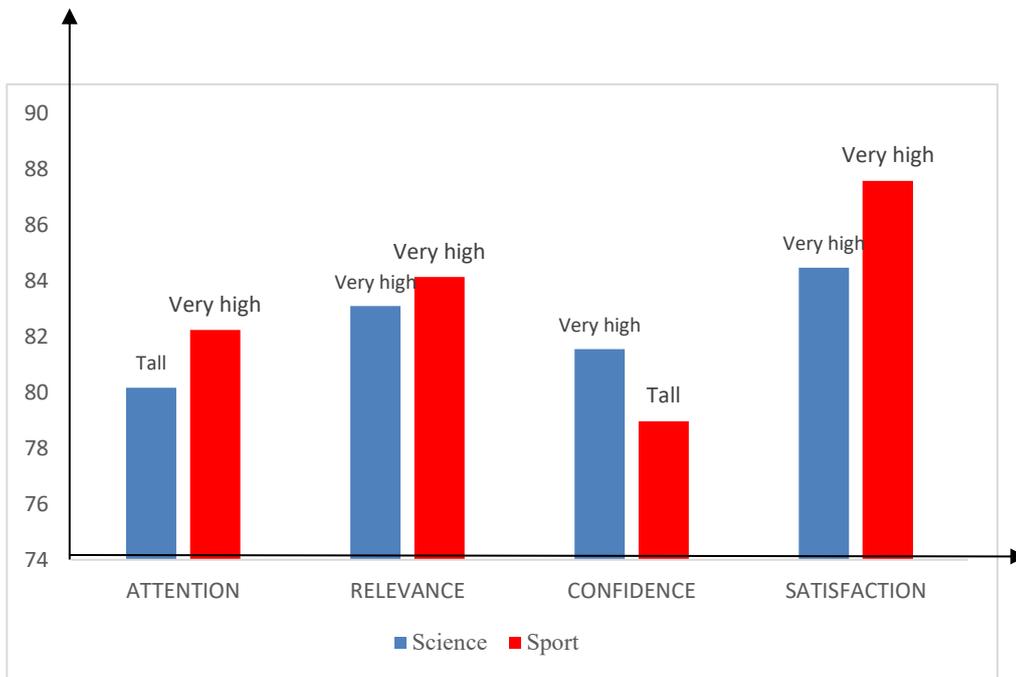


Figure 2 Student Learning Motivation Profile (ARCS Model)

## Discussion

Empirical evidence obtained from this study indicates a radical transformation in students' conceptual understanding, validated by the experimental class achieving an N-Gain score of 0.70 (high category), which stands in stark contrast to the control class's score of 0.21. This significant disparity elucidates the failure of conventional teaching methods which rely heavily on verbal descriptions and static two-dimensional images to convey the complex, abstract nature of the human reproductive system. Rahmawati et al. (2024) argue that the fundamental barrier in biology education is the disconnect between macroscopic phenomena and microscopic mechanisms. The "Differentiated Smart Flipbook" developed in this research successfully bridges this cognitive gap by integrating 3D visualization and QR Code technology. These features allow students to manipulate virtual objects, effectively transforming intangible concepts such as gametogenesis and fertilization into concrete, observable entities. By rotating and zooming in on anatomical structures, students can build a robust mental model that is impossible to achieve through text-based learning alone.

Cognitive mechanisms underlying this success can be analyzed through the lens of the Cognitive Theory of Multimedia Learning. Mayer (2020) posits that the human brain processes information through two distinct channels: visual and auditory. Traditional instruction often overloads the auditory/verbal channel while underutilizing the visual one, leading to cognitive overload and poor retention. In contrast, the multimedia approach used in this study distributes the cognitive load across both channels. The synergy between the explanatory text (verbal) and the interactive 3D models (visual) facilitates dual coding, which significantly enhances transfer learning and long-term memory retention. This finding refutes the efficacy of static digital media, such as the basic e-modules developed by Sugianto et al. (2023), which merely digitize textbook content without leveraging the dynamic potential of technology. Consequently, this study confirms that interactivity is not merely an aesthetic addition but a pedagogical necessity for reducing misconceptions in abstract biological topics, as suggested by Wahyuni et al. (2019).

Specific analysis of the Science Excellence Class, a group statistically dominated by visual learning profiles, reveals that their cognitive engagement is highly dependent on the "granularity" of the information presented. Students in this demographic possess a natural inclination to process information through spatial imagery and diagrammatic logic. Suparno (2021) emphasizes that for visual learners, the clarity of diagrams is the key to dismantling misconceptions. The *Differentiated Smart Flipbook* caters to this need by providing high-resolution anatomical visualizations that allow for deep inspection. Unlike static textbook diagrams which are often simplified or schematic, the 3D models in this media allow science students to perform virtual dissections. They can zoom in to observe the structural difference between spermatogonia and spermatozoa or trace the path of the ovum through the fallopian tube with precision. This level of detail satisfies their analytical curiosity, shifting their learning process from rote memorization of labels to a systemic understanding of physiological functions.

The most profound and novel finding of this research is the media's success in accommodating the Special Sports Class, a demographic traditionally marginalized in text-heavy science curriculums due to their strong kinesthetic preference. Tomlinson (2001) asserts that kinesthetic learners struggle with passive absorption of information and require physical activity or "hands-on" manipulation to construct meaning. The *Differentiated Smart Flipbook* addresses this challenge by converting the learning experience from passive viewing to active manipulation. Features that allow 360-degree rotation of 3D objects and drag-and-drop simulations provide a "pseudo-tactile" experience a virtual sense of touch.

Engagement for sports students is further sustained through the gamified elements of the media. Widodo et al. (2023) note that students with high physical energy levels are prone to boredom in conventional lecture settings but thrive in interactive environments that offer immediate feedback. The act of navigating the interface, interacting with touch-screen simulations, and solving puzzle-like quizzes channels their motor energy into focused cognitive activity. This interactivity creates a virtual lab experience that substitutes the need for physical props, allowing them to learn by doing rather than just listening. The statistical homogeneity in post-test results between the Science and Sports classes serves as powerful evidence that the achievement gap is not a result of differing intellectual capabilities, but rather a symptom of rigid pedagogical approaches. By aligning the delivery method with their modality, sports students proved capable of achieving academic excellence comparable to their science counterparts.

Reproductive health education in the Indonesian context is uniquely complicated by social norms and cultural taboos, which often silence students in the classroom. Rukman (2024) previously attempted to mitigate this issue using a physical Surprise Box, which allowed anonymous questions but lacked immediacy and relied on the teacher's presence. This study advances that solution by digitizing the safe space through the integration of an AI-powered Chatbot. This feature creates a psychologically safe environment where students can inquire about sensitive topics such as menstruation, wet dreams, or reproductive hygiene without the fear of social judgment or peer ridicule. The anonymity provided by the machine interface encourages openness that is rarely achieved in face-to-face interactions.

Interactions between students and the Chatbot facilitate self-regulated learning, a critical competency for the 21st century that mastering biological concepts requires deep questioning; the Chatbot removes the barrier. Chen and Tsai (2025) note that interactive systems that provide instant feedback significantly boost students' confidence and willingness to explore beyond the curriculum. Unlike a teacher who may have limited availability or unconscious biases, the AI provides objective, data-driven responses in real-time. This immediate gratification of curiosity maintains the momentum of inquiry. Abaniel (2020) highlights the importance of this questioning process. Therefore, the integration of AI in this media serves a dual purpose: it acts as a cognitive scaffold for answering academic questions and as an emotional buffer that respects the privacy and psychological comfort of adolescents navigating the complexities of puberty.

Analysis of the motivation questionnaire reveals a substantial uplift across all dimensions of the ARCS model (Attention, Relevance, Confidence, Satisfaction). Keller (2009) argues that attention is the prerequisite for learning, yet it is the hardest to maintain in the digital distraction era. The gamified elements and modern visual aesthetics of the flipbook successfully captured and sustained students' attention, preventing the boredom often associated with text-heavy biology textbooks. Widodo et al. (2023) corroborate this, stating that gamification in educational tools transforms the learning process from a passive duty into an active challenge.

Relevance was established by connecting abstract theories to students' real-life bodies and experiences, addressing the "Why do I need to learn this?" question. Johansen et al. (2023) emphasize that technology enhanced learning achieves maximum effectiveness when it fosters authentic experiences. Furthermore, the Confidence aspect was bolstered by the interactive quizzes and the Chatbot, which allowed students to test their understanding privately before being assessed publicly. This scaffolding builds a sense of competence. Finally, Satisfaction was derived from the intrinsic reward of understanding complex mechanisms that were previously opaque. The positive correlation found between motivation scores and learning outcomes in this study reinforces the notion that emotional readiness is inextricably linked to cognitive success. When students feel confident and engaged, their cognitive resources are fully available for learning.

Rote memorization of anatomical terms has long been the default strategy for students struggling with biology, leading to superficial knowledge that fades quickly. Suparno (2021) defines this as a failure of concept internalization. The *Differentiated Smart Flipbook* shifts the focus from memorization to contextual understanding. By presenting case studies and problem-solving scenarios within the media, students are compelled to apply their knowledge to solve problems, rather than merely recalling facts. Widiyatmoko and Shimizu (2018) stress that misconceptions in science often stem from a lack of contextualization. By simulating real-world biological processes, the media allows students to verify their understanding and correct their own misconceptions dynamically. This process cultivates critical thinking skills and scientific literacy, preparing students not just for exams, but for making informed health decisions in their daily lives.

Theoretically, this research contributes to the expansion of the Technological Pedagogical Content Knowledge (TPACK) framework by integrating the learner's profile as a central variable. Arsyad (2024) states that modern learning media must possess elasticity to serve diverse user characteristics for learning to be meaningful. This study validates that adaptive technology acts as an academic equalizer, dismantling the walls between academic (Science) and non-academic (Sports) students. Sitorus (2025) argues that the ultimate goal of the Merdeka Curriculum is competency, not just content delivery. This research provides a blueprint for achieving that goal, proving that educational equity is attainable when technology is orchestrated to respect and respond to the unique learning styles of every student.

## **CONCLUSION**

This study reveals empirical facts that transcend initial predictions, where the integration of 3D visualization and interactive simulations in the *Differentiated Smart Flipbook* successfully nullified the academic achievement gap between student groups with opposing learning profiles. The most striking finding is the surge in performance of the Special Sports Class (predominantly kinesthetic), which was able to match the concept mastery achievements of the Science Excellence Class (predominantly visual). This phenomenon debunks the stereotypical assumption that students with non-academic talents possess lower cognitive capacities in abstract biological material. This success indicates that learning barriers are not caused by student deficits, but rather by the rigidity of conventional teaching methods that fail to provide a "psychomotor channel" for kinesthetic learners to grasp microscopic concepts.

Theoretically, this study offers a new perspective within the Technological Pedagogical Content Knowledge (TPACK) framework by positioning the student profile variable (*learner knowledge*) as a primary determinant of successful technology integration. This research challenges the validity of the "static digitization" approach (such as standard PDF e-modules), which has proven insufficient for reducing misconceptions. The original contribution of this article lies in the synergistic model between content differentiation and Artificial Intelligence (AI Chatbot), which functions not only as a cognitive aid but also as a psychological solution to address cultural taboos in sexuality education. This approach enriches science education literature by proving that adaptive technology can act as an instrument of inclusivity that humanizes the learning process through personalization and privacy.

Interpretation of this study's effectiveness must consider several methodological and technical limitations. The primary limitation lies in the measurement design of the motivation variable, which was only conducted at the end of the learning process (*post-treatment*); consequently, this study only captures the final level of motivation, not the comparative improvement (*gain*) from the initial state. Additionally, the Chatbot feature used has constraints regarding the teacher control mechanism; the current system is only capable of recording access frequency without being able to monitor the content of student inquiries in real-time, so verification of inquiry activities still relies on manual methods via screenshots sent by students. Future research agendas are strongly advised to develop AI algorithms integrated with a Learning Management System (LMS) so that inquiry tracks can be monitored automatically, as well as to expand the sample coverage to more heterogeneous school demographics to test the consistency of these findings on a broader scale.

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