Assimilation: Indonesian Journal of Biology Education
ISSN 2621-7260 (Online)
Journal homepage: https://ejournal.upi.edu/index.php/asimilasi

Interactive animation-based flipbook to improve secondary students' understanding of the human digestive system

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OPEN ACCESS

ARTICLE HISTORY
Received: 30 September 2025
First Revised: 23 November 2025
Accepted: 29 November 2025
First Available Online: 30 November 2025
Publication Date: 30 November 2025

KEYWORDS
Interactive
Animation-based
Flipbook
Students' understanding
Human digestive system

ABSTRACT

Low student comprehension of the human digestive system persists, largely due to the material's abstract nature and difficulty in visualization. Existing pedagogical tools, such as standard textbooks and lectures, are inadequate, lacking the interactive visual mechanisms necessary to bridge this conceptual gap. In response to these instructional limitations, the current research seeks to leverage technology to provide effective visualization. Specifically, this study aims to develop an innovative interactive animation-based flipbook to significantly improve secondary students' understanding of the human digestive system. The study uses a Research and Development (R&D) method with the ADDIE model, which includes the stages of analyze, design, development, implementation, and evaluation. The research subjects are 11th-grade students from an Indonesian public senior high school, while the research object is an interactive animation-based flipbook developed using the Heyzine Flipbook Maker application. Validation results showed an average feasibility of 91.7% (very feasible category), firmly confirm that the developed module is highly suitable and practical for implementation. Effectiveness testing indicated a significant increase in student understanding, evidenced by an N-Gain score of 0.72 in the experimental class, substantially surpassing the 0.29 N-Gain score recorded in the control class. Findings confirmed the high effectiveness of the innovative interactive animation-based flipbook as a pedagogical tool in substantially improving secondary students' conceptual understanding of the abstract concepts.

INTRODUCTION

Learning is a process that must be carried out in the world of education with the aim of enabling students to achieve optimal results. In essence, learning is a complex understanding. The learning process can be carried out anywhere and anytime. Through this process, a person will acquire knowledge, skills, habits, and values that will be useful in preparing to meet their daily needs (Jasum et al., 2021). The subject of biology involves students' skills in understanding abstract concepts (Jansen et al., 2019). Educators are expected to be able to design interactive media for the teaching and learning process, so that students are expected to be able to understand biological concepts. Biology is one of the subjects with the most concept because it covers all living things, from humans to microscopic living things (e.g. Birzina, 2023; Farahani et al., 2023).

The concept studied in Grade XI about systems in living things is one of the most complex subjects, accompanied by terminology and various physiological processes. One of these is the human digestive system. This material is quite difficult for students to understand because it covers a wide range of topics, such as the detail stages of the digestive system, accompanied by abstract material that cannot be seen directly (A'yun et al., 2024). This is supported by research conducted by Salsabila et al. (2025), which states that in biology learning, especially on the topic of the digestive system, there are challenges that arise due to the complexity of concepts and the close relationship between the structure and function of organs. If the material is delivered using conventional methods, students tend to have difficulty understanding the interrelationships between the parts of the system. Learning difficulties are a condition in which students experience a decline in their academic performance. Based on several studies that have been conducted, the factors that cause students to have difficulty understanding digestive system concept are motivation, media, material, and learning methods (e.g. Farahani et al., 2023; Muna et al., 2024).

Teaching media play an important role in the learning process, as an intermediary for teachers to convey relevant information to all students. Teaching media are also used to stimulate thinking, perception, attention, and willingness to participate in the learning process (e.g. Aswanti & Isnaeni, 2023; Serap et al., 2023). Efforts to utilize technology in education involve implementing it in teaching media. Well-designed learning tools containing interactive content and illustrations can encourage students to participate in the learning process, making it more interactive and effective (A'yun et al., 2024). Therefore, innovation is needed for teaching media that can facilitate and influence students' learning outcomes to be better (Fitriyana et al., 2025). One teaching media that can contain, display, and convey learning information in audiovisual form is a flipbook. Flipbooks are a learning media that can be utilized because they are systematically designed to contain learning content such as text, images, videos, and other elements that are more interactive than textbooks in general (e.g. Roemintoyo & Budiarto, 2021; Serap et al., 2023; Usman et al., 2024).

Flipbooks can provide visual and auditory stimuli that can improve students' memory (e.g. Bunari et al., 2024; Susilo et al., 2025). Three-dimensional interactive books with moving screens are called flipbooks. Flipbooks are also one of the learning tools that are expected to make lessons interesting and enjoyable. In terms of conveying information, entertainment, and teaching, flipbooks as audiovisual media are 70% more effective in attracting students' interest and attention in supporting student learning and development. Flipbooks can also help students become more skilled in using media, information technology, and information technology to meet modern competency requirements. In addition, the use of interactive flipbooks can also increase student engagement in the learning process because it combines elements of text, images, animation, and sound that make learning more meaningful (Firdaus et al., 2023). This medium allows students to learn independently or in groups in a more engaging way, and helps teachers deliver material more effectively and efficiently. Thus, flipbooks not only function as a learning medium, but also as a means of developing 21st-century skills that support students' critical thinking, creativity, and literacy (Hadi et al., 2025).

DOI: https://doi.org/10.17509/aijbe.v8i3.91230
e-ISSN 2621-7260

Therefore, this study aims to develop a learning medium in the form of an interactive animation-based flipbook to improve the understanding of 11th grade students on the subject of the human digestive system. The purpose of this study was to develop learning media in the form of interactive animation-based flipbooks on the subject of the human digestive system in order to improve the understanding of 11th grade students and create a more interesting, effective, and interactive learning process.

METHODS

This study used the Research and Development method with the ADDIE model, which consists of five main stages, namely analyze, design, development, implementation, and evaluation (Gall et al., 2003). This model was chosen because it provides systematic steps in developing effective learning media. The study was conducted from August to October 2025. The research subjects were one subject matter expert, one media expert, one learning expert, and 70 11th grade students. Meanwhile, the research object was a flipbook based on interactive animation developed using Heyzine Flipbook Maker for digestive system material.

The research stages began with a needs analysis (analyze) through interviews with biology teachers and curriculum studies to identify students' learning difficulties. The results of the analysis showed that students' understanding of the digestive system concept was still low due to the limitations of visual media and the lecture method used. Next, in the design stage, the content, flipbook structure, and interactive navigation were designed. In addition, research instruments such as validation sheets, response questionnaires, and pretest-posttest questions were also designed. Then, the development stage involves product development, which is then validated by experts to assess the suitability of the content, media, and learning. The validation process was conducted by experts in both media and learning content. A five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), was utilized in the validation instrument to rate each statement. Validation scores were subsequently converted into a percentage and categorized based on the criteria presented in Table 1. The criteria is adapted from Nurhayati et al (2025). After revisions are made, the implementation stage is carried out using a pretest-posttest control group design, in which the experimental class will use flipbooks and the control class will use printed worksheet that they usually use. Finally, the evaluation stage is carried out through analysis of the validation results and student learning outcomes to assess the effectiveness of the product produced.

The data collection techniques used include interviews, questionnaires, and learning outcome tests. Effectiveness analysis was conducted by calculating the increase in learning scores using the Normalized Gain (N-Gain) formula, which compares the pretest and posttest scores between the experimental class and the control class. The N-Gain calculation results were then categorized into three criteria, namely high (N-Gain > 0.7), moderate (0.3 ≤ N-Gain ≤ 0.7), and low (N-Gain < 0.3). Based on the analysis results, the effectiveness of the media was considered good if the N-Gain value showed a significant increase in the experimental class compared to the control class.

Table 1. Likert Scale Validity Test

Percentage (%)	Eligibility Criteria
80-100	Very suitable
66-79	Suitable
56-65	Fairly suitable
40-55	Less suitable
30-39	Unsuitable

DOI: https://doi.org/10.17509/aijbe.v8i3.91230
e-ISSN 2621-7260

Then, data analysis was conducted to determine the effectiveness of interactive animation-based flipbooks. To determine the effectiveness of flipbooks, tests were conducted in the form of post-tests and pre-tests consisting of 20 multiple-choice questions. The normalized N-Gain formula was used in this study, as shown below.

$$\text{N-Gain}=\frac{Postest\ score-pretest\ score}{Max\ score-pretest\ score}$$

Based on the above formula, the criteria for the effectiveness level of flipbooks are presented in table 2. These N-Gain values are classified according to the criteria established by Hake (1998) and commonly presented in tabular form (Ayunda & Rohani, 2025).

Table 2. Normalized Gain Criteria (N-Gain)

N-Gain	Criteria
>0,7	High
0,3≤N-Gain>0,7	Medium
N-Gain<0,3	Low

RESULTS AND DISCUSSION

The application of research on developing interactive animation-based flipbooks begins with the analysis stage, which includes material analysis, media analysis, and needs analysis (e.g. Mahendri et al., 2023; Mutiara et al., 2025; Syifah et al., 2025). Material analysis aims to evaluate the suitability of learning materials with the curriculum and determine the concepts to be presented in the media. Media analysis is carried out to review the characteristics, forms, and appropriate technologies to be used so that the media can function optimally and attractively. Meanwhile, needs analysis is conducted to identify actual conditions in the field, such as students' learning difficulties, availability of facilities, and teachers' needs for innovative learning media. This analysis stage is very important because it forms the basis for determining the direction of media development so that it is in line with learning objectives and user characteristics (Kurniawati et al., 2021).

The analysis stage was carried out through interviews and observations with biology teachers. The results of the material analysis from the interviews with biology teachers showed that the biology material that was difficult for students to understand in biology learning was the human digestive system concept, which was considered quite complex because it contained various scientific terms in understanding the digestive process. Furthermore, the results of the media analysis show that teachers generally use conventional media such as printed books and explanations on the blackboard. Teachers also stated that more innovative learning media are needed to help students understand. The results of the needs analysis show that students are less enthusiastic about participating in biology lessons, especially on the subject of the human digestive system, because the lessons are still monotonous and dominated by lectures and textbooks without the support of interesting learning media. Therefore, the overall results of this analysis stage show that there are no available learning media that can help students understand the concept of the digestive system visually and interactively. This condition forms the basis for the need to develop interactive animation-based flipbook media as an innovation that can improve students' understanding of the concept of the digestive system and student engagement in the learning process.

Furthermore, at the design stage, the flipbook was developed systematically, taking into account aspects of content, appearance, and interactive user functions. The biology concept presented is intended for 11th grade high school students on the topic of the human digestive

DOI: https://doi.org/10.17509/aijbe.v8i3.91230
e-ISSN 2621-7260

system, which covers four main chapters, namely food, the digestive system, the digestive process, and disorders and their prevention. Each chapter is equipped with interactive features that not only facilitate online users but also encourage students to actively engage in the learning process. These features include: (1) Brain Trigger, which consists of stimulating questions and animated illustrations designed to stimulate students' curiosity and critical thinking before studying the core material; (2) Brainflix, which is interactive video or visual animation content, where users can click on certain icons to display additional information or enlarge certain visual parts of the digestive system; and (3) Brain Chek, which is an interactive quiz-style exercise that provides feedback on students' answers, creating a two-way communication between the media and users.

These features make Facebook not only easily accessible online but also functionally interactive, whether through animated visuals, responsive navigation, or feedback-based evaluation (Assalimi & Indana, 2025). Overall, the design stage shows that the developed flipbook has fulfilled the principles of effective learning media, namely being visually appealing, informative in terms of content, and interactive in its use. The cover and contents of the flipbook can be seen in Figure 1 below. The cover and contents of the flipbook can be seen in Figure 1 below.

Figure 1. Cover display of flipbook

During the development stage, the interactive animated flipbook was revised based on input from subject matter experts, media experts, and learning experts. Validation was carried out to ensure that the product was not only visually appealing but also effective in improving students' understanding of biological concepts, particularly the human digestive system (e.g. Bers, et al., 2023; Mutiara et al., 2025).

Validation Results by Subject Matter Experts

The assessment was carried out by subject matter experts, where the assessment scores were converted into percentages and then adjusted according to existing criteria. The assessment criteria used by expert lecturers were used to improve the quality of the product. The aspects assessed were: (1) content suitability; (2) depth of material; and (3) presentation of material (Nurbekova, et al., 2023). The data from the media assessment can be seen in table 3.

Table 3. Results by Subject Matter Experts

Assesment Indicators	Percentage	Criteria
Feasibility of Content	100%	Very Suitable
Depth of Content	94%	Very Suitable
Presentation of Content	94%	Very Suitable
Average	96%	Very Suitable

DOI: https://doi.org/10.17509/aijbe.v8i3.91230
e-ISSN 2621-7260

The results of the assessment by subject matter experts show that the flipbook received an average score of 96% in the "highly acceptable" category. This assessment covers the aspects of content suitability (100%), depth of material (94%), and presentation of material (94%). This high score indicates that the content is in line with the basic competencies to be achieved, uses clear and communicative language, and is presented with attractive and easy-to-understand visuals. Thus, in terms of content, language, and presentation, this flipbook meets the criteria as a learning resource suitable for use in the biology learning process.

Validation Results by Media Experts

The assessment was conducted by media experts, where the assessment results were in the form of scores that were then converted into percentages and adjusted to existing criteria. The criteria for the assessment results of expert lecturers were used to improve product quality. The aspects assessed were: (1) Flipbook presentation; (2) Language; and (3) Visual appearance. The data from the media assessment can be seen in Table 4.

Table 4. Results by Media Experts

Assesment Indicators	Percentage	Criteria
Flipbook Presentations	81%	Very Suitable
Language	100%	Very Suitable
Visual Appearance	86%	Very Suitable
Average	89%	Very Suitable

The results of the assessment by media experts showed an average score of 89% with a rating of very good. The aspects assessed included flipbook presentation (81%), language (100%), and visual appearance (86%). These results indicate that the developed media meets the principles of learning media suitability in terms of design, readability, and ease of use. Although the presentation aspect can still be improved, overall, this flipbook has been assessed as attractive, interactive, and capable of helping students understand the material more effectively.

Validation Results by Learning Experts

The assessment was conducted by learning experts, where the assessment results were in the form of scores that were then converted into percentages and adjusted to existing criteria. The criteria for the assessment results of expert lecturers were used to improve product quality. The aspects assessed include: (1) content; (2) depth of content; and (3) presentation of content. The data from the assessment by the media can be seen in the table 5.

Table 5. Results by Learning Experts

Assesment Indicators	Percentage	Criteria
Content	78,5%	Suitable
Depth of Content	100%	Very Suitable
Presentation of Content	92%	Very Suitable
Average	90,1%	Very Suitable

Assessment by learning experts showed an average score of 90.1% with a rating of very good. The aspects assessed included content 78.5%, depth of material 100%, and presentation of material 92%. These results indicate that the flipbook has met its learning objectives and is capable of supporting the teaching and learning process in the classroom. Learning experts assessed that the content was presented systematically, with adequate depth of concept and a display that was able to attract students' interest in learning. However, the content aspect still needs a little refinement to be more balanced with the depth of material presented.

DOI: https://doi.org/10.17509/aijbe.v8i3.91230
e-ISSN 2621-7260

Next is the implementation stage, which is carried out after the experts' validation has met the criteria. At this implementation stage, the researchers conducted tests on students in control class and experimental class using test questions. These tests were conducted to see the effectiveness of interactive animation-based flipbooks. The test results can be seen in Table 6.

Table 6. Result of student comprehension tests

Class	Average pretest score	Average postest score	Percentage of test completion
Control class	36	50	14%
Experiment class	43,14	84,29	91%

Based on the results of the comprehension test above, the experimental class that used interactive animation-based flipbooks was able to improve their comprehension, with a test completion rate of 91% compared to the control class, which only achieved 14%. Furthermore, the significance level of the test results was calculated using the N-Gain score test. The results of the calculation can be seen in Table 7.

Table 7. N-Gain score test results

Class	N-Gain score	Criteria
Control class	0,29	Low
Experiment class	0,72	Moderate

Based on the N-Gain results above, the N-Gain value in the control class was 0.29, which is classified as low, while in the experimental class it was 0.72, which is classified as moderate. This shows that the use of interactive animation-based flipbooks is more effective in improving student understanding than conventional learning, which is lecture-based and limited to existing textbooks. The level of significance in the experimental class can be explained by the fact that the flipbook developed is able to present material visually and interactively, thereby helping students understand abstract concepts of the digestive system more easily. The attractive animations also increase student motivation and focus. This is in line with Mayer's Cognitive Theory of Multimedia Learning, which asserts that the combination of text and visuals can strengthen the knowledge formation process (e.g. Mayer, 2024).

Based on the results of the study, the evaluation process of interactive animation-based flipbooks was carried out through several stages of assessment by experts and effectiveness tests on students. The results of validation by subject matter experts showed that the developed media obtained an average percentage of 96% with a very feasible criterion. This shows that the content of the flipbook is in accordance with basic competencies, learning indicators, and the accuracy of the scientific concepts presented. Furthermore, the assessment by media experts obtained an average score of 89% with a very feasible criterion, which means that the appearance, animation, interactivity, and navigation in the flipbook are considered attractive and easy to use by students. The validation results from learning experts obtained an average percentage of 90.1% with very feasible criteria, indicating that this media is in accordance with pedagogical principles, material delivery strategies, and supports the achievement of learning objectives.

In addition to expert assessment, effectiveness testing was also conducted on students by comparing learning outcomes between the control class and the experimental class. The N-Gain score in the control class was 0.29, which is in the low category, while in the experimental class it reached 0.72, which is in the moderate category. These differences show that the use of interactive animation-based flipbooks can significantly improve students' understanding of the human digestive system compared to conventional learning methods. Thus, based on the results of validation and effectiveness tests, it can be concluded that interactive animation-based flipbooks are suitable and effective for use as a learning medium for teaching the human digestive system.

DOI: https://doi.org/10.17509/aijbe.v8i3.91230
e-ISSN 2621-7260

The use of flipbooks has been proven to improve students' understanding of concepts while fostering motivation to learn through more engaging and interactive presentation of material (e.g. A'yun et al., 2024; Velinda et al., 2024; Juniati et al., 2025). In the learning process, this medium not only makes it easier for teachers to explain abstract material such as the human digestive system, but also encourages students to actively observe, discuss, and understand each stage of the process through dynamic visual displays (Damayanti, et al., 2024). The integration of text, images, audio, video, and interactive animations in flipbooks makes learning more interesting and helps students understand concepts in a concrete way. The results of the study by A'yun et al. (2024) show that the use of flipbooks has a high level of validity and received very positive responses from students because of its attractive and accessible design. Similar findings by Juniati et al. (2025) also show an increase in students' conceptual understanding with an N-Gain value of 0.45 in the moderate category. Meanwhile, Velinda et al. (2024) revealed that web-based interactive flipbooks with varied animation, audio, and visual elements are considered feasible and effective in attracting students' interest in learning and honing their critical thinking skills. Subsequent research is recommended to investigate the impact of the flipbook on other learning aspects, such as students' critical thinking skills or motivation in learning abstract science concepts. Also, future studies should focus on implementing the interactive animation-based flipbook across a broader population and varying educational levels to confirm the generalizability of these findings.

CONCLUSION

The flipbook contains a combination of text, images, videos, and interactive animations designed to make it easier for students to understand abstract concepts in human digestive system material. The results of validation by experts show that the developed flipbook is classified as “highly feasible” for use as a learning medium. The study's findings validate the interactive animation-based flipbook's efficacy in addressing the abstract nature of the material and fostering conceptual understanding among secondary students.

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Acknowledgment

Researcher would like to thank the university which funded this research and the participants who were involved in this research.

Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

How to Cite this Article

Harahap, R.S., Harahap, F., Rahma, M., Wijaya, R., Salsabila, N., & Hermaliana, N. (2025). Interactive animation-based flipbook to improve secondary students' understanding of the human digestive system. *Assimilation: Indonesian Journal of Biology Education, 8*(3), 327-336. https://doi.org/10.17509/aijbe.v8i3.91230