Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram
https://e-journal.undikma.ac.id/index.php/prismasains/index
e-mail: prismasains.pkpsm@gmail.com

July 2025. Vol. 13, No. 3
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 619-633

Development of Interactive Flipbook Media with STM (Science Technology Society) Approach to Improve Learning Outcomes on Genetic Mutation Material

Yofi Dewi Parmita, * Sarwo Danuji, Hanif Rafika Putri
Biology Education Study Program, FKIP, Universitas PGRI Argopuro Jember, Jl. Jawa No.10, Jember 68121, Indonesia
* Corresponding Author email: bilawa71@gmail.com

Received: January 2025; Revised: June 2025; Published: July 2025

Abstract

This study aims to determine the feasibility of interactive flipbook media as learning media, determine student responses to interactive flipbook media with the STM (Science Technology Society) approach and improve student learning outcomes in learning biology, especially on genetic mutation material. This research is using the Research and Development (R&D) method with the ADDIE model (Analyse, Design, Develop, Implement, and Evaluate). his research was conducted at Baitul Arqom High School, Jember City, involving 25 students of class XII as subjects. The research design used was one-group pretest-posttest using an instrument in the form of 20 multiple choice questions to assess the improvement of learning outcomes to determine the difference in learning outcomes before and after the use of media. The media feasibility assessment was conducted by three experts, consisting of two biology education lecturers and one biology teacher. Meanwhile, students' responses to the learning media were obtained through the distribution of questionnaires. Based on the results of the study, it shows that the feasibility by material expert validators is 80%, media experts are 82%, and practitioner experts are 81% with an average percentage of 81% very feasible. Student responses to interactive flipbook media with the Science Technology Society (STM) approach scored 87% responded positively with a good category. The trial results showed an increase in student learning outcomes with an average N-Gain of 0.76, which is classified in the high category, as well as a normal distribution of N-Gain data. Overall, it can be concluded that the development of interactive flipbook media based on the Science Technology Society (STM) approach received a good response as learning media and proved effective in improving student learning outcomes, so it is feasible to use in the learning process.

Keywords: Interactive Flipbook, STM approach, learning outcomes, ADDIE

How to Cite: Parmita, Y., Danuji, S., & Putri, H. R. (2025). Development of Interactive Flipbook Media with Science Technology Society Approach to Improve Learning Outcomes on Genetic Mutation Material. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *13*(3), 619–633. https://doi.org/10.33394/j-ps.v13i3.15422

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INTRODUCTION

Advances in science and technology (IPTEK) in the 21st century have brought significant changes in various aspects of life, including education. Mastery of information and the ability to process knowledge is very important, requiring individuals to have the ability to think critically, logically, and creatively (Nurhalisa & Sukmawati, 2022). In this digital era, technology not only acts as a means of social communication, but also becomes an integral part of the learning process at school, including in biology subjects.

Biology as a complex discipline requires high analysis, synthesis and evaluation skills. Genetic mutation material, especially the polyploidization process in orchid plants, is an example of a biological phenomenon that requires in-depth conceptual understanding and application of technology in the world of agriculture. Polyploidization that can occur naturally

or through technology such as the use of colchicine has a significant impact on genetic variation that can improve the quality and aesthetic value of plants (Gladys & Fitri, 2024).

Although this material is important, the implementation of genetic mutation learning in class XII SMA Baitul Arqom Balung still faces various obstacles. Observations show that learning still relies on printed books that are static, less illustrative, and minimal interactive media. This contributes to low student interest in learning and a less than optimal level of understanding. Data from daily test results show that the majority of students have not reached the Minimum Completion Criteria (KKM), indicating the need for media innovation more interesting and effective learning.

Flipbook is a form of multimedia in learning in the form of electronic books that can be accessed via cell phones or monitor screens, and allows users to open each page like a physical book. In addition to appearing like a regular book, flipbooks also function as interactive media by including elements such as video, audio, images, and animation, in addition to plain text (Mursidi et al., 2022). Digital flipbooks are able to significantly improve students memory and understanding of various science concepts, with the presentation of material that is easier to understand (Oronce & Manalo, 2021). Flipbooks can facilitate the learning process for teachers and students interactively. Flipbook learning media is very flexible and easy to use, allowing students to learn anytime and anywhere (Arisandhi et al., 2023).

Previous research supports the effectiveness of flipbook media in learning biology. (Ayuardini, 2023) developed a flipbook-based interactive e-module to improve understanding of biological concepts, and the results showed a high level of feasibility with an average student response score of 80% in the "good" category. Another study by (I. P. Sari et al., 2024) showed that flipbook-based e-modules enrich the learning experience and serve as an attractive assessment media. Furthermore, (Darmansyah et al., 2024)reported that the use of interactive flipbook e-modules significantly improved student learning outcomes, with an N-Gain value of 0.71 (high category).

The learning approach also plays an important role in the success of the learning process. The Science Technology Society (STM) approach integrates aspects of science, technology, and the social context of society in learning, which can encourage active student involvement and critical and creative thinking skills (Syawal, 2024). The STM model allows students to link science concepts with real issues in society, so that learning becomes more relevant and meaningful (Rahmat et al., 2023).

Previous research by (Irfandi., 2019) showed that the STM approach can improve students scientific attitudes such as curiosity and openness to new ideas. (W. Sari N. ,. & Ahmad, 2021) also revealed that the use of STM-based teaching materials is effective in learning basic science. However, in learning genetic mutation material at Baitul Arqom Balung High School, the STM approach has not been applied optimally, and the learning media used are still limited to printed books and other conventional media that are less interactive.

Based on observations at SMA Baitul Arqom Balung, it is known that learning on genetic mutation material is still dominated by the use of conventional media such as printed books that are static and less interesting. This condition has an impact on the low level of student involvement and has not optimized their learning outcomes. In addition, the utilization of innovative learning media at the school is still relatively minimal, especially in integrating contextual approaches such as Science Technology Society (STM). Based on these problems, this research focused on developing interactive flipbook learning media based on the Science Technology Society (STM) approach. This study aims to determine whether the media developed is feasible to use in learning, understand how students respond to the media, and see how effective this media is in helping improve student learning outcomes on genetic mutation material.

METHOD

This research applies the Research and Development (R&D) approach using the ADDIE development model which consists of five systematic stages, namely Analysis, Design, Development, Implementation, and Evaluation. This model was chosen because it provides a structured framework and allows the development of learning products that can be customized through a continuous evaluation and revision process. The ADDIE model is very relevant to be applied in educational research because it is flexible and able to produce tested learning innovations (Okpatrioka, 2023). The stages in the ADDIE method are described in the modified ADDIE stage flow as shows in Figurw 1.

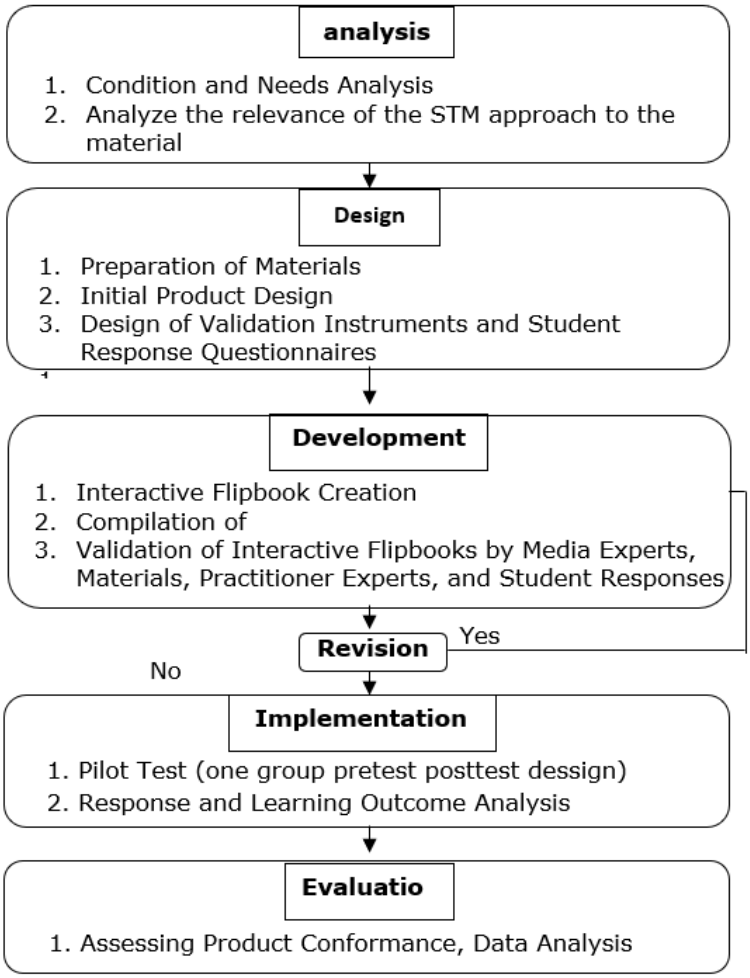


Figure 1. Stages of the modified ADDIE model (Zuniari et al., 2023).

The learning media development process in this study follows the stages of the ADDIE model which has been modified to suit the needs of the field. The chart shows the workflow starting from the analysis stage.

This stage aims to identify the real conditions of the biology learning process at Baitul Arqom High School, Jember, especially in class XII which totals 25 students, as well as the needs that must be met for learning to be effective. Researchers conducted interviews with biology teachers at the school. The results of the analysis show that learning still uses conventional methods such as lectures and textbooks, which are less able to accommodate students' needs for more interactive and contextual learning media. The limited learning resources that support the Science Technology Society (STM) approach also encourage the development of innovative media in the form of interactive flipbooks. Curriculum analysis was conducted to ensure the suitability of genetic mutation material with applicable competency standards. The Science Technology Society (STM) approach is considered important to

connect scientific concepts with technological applications and their impact in social life, so that learning becomes more relevant and meaningful.

The Design stage in this study aims to systematically design interactive flipbook media based on the Science Technology Society (STM) approach. Design activities begin with the preparation of genetic mutation learning materials that are in accordance with the class XII SMA curriculum and the results of the analysis of student needs. The material is prepared by taking into account the elements of science, technology, and society so that learning is not only oriented to biological concepts, but also applicable and contextual in everyday life. Things that need to be considered are ensuring the facilities and infrastructure needed during product development, determining the product description, and determining the data structure used, such as images, videos, animations, audio, materials and evaluation questions that support the delivery of genetic mutation material, especially polyploids. The application used by researchers to edit and create flipbook designs is the canva application. Researchers also use the heyzine flipbook website to access interactive flipbooks. The goal is to create media that is attractive, easy to use, and encourages active student participation. At this stage, validation instruments were also prepared which included aspects of material, media design, and the Science Technology Society (STM) approach. In addition, a student response questionnaire was also prepared which will be used at the implementation stage to measure their perceptions and involvement in the developed media.

The Development stage is a continuation of the design process which is carried out by rearranging and aligning the appearance so that the flow of material presentation remains systematic and supports learning objectives. The initial product that has been developed is then validated by three experts, namely two biology education lecturers as material and media expert validators, and one biology teacher as a field practitioner. This validation is to determine the feasibility level of interactive flipbook media. content, appearance, interactivity, and suitability with the Science Technology Society (STM) approach. Input from the validators was used as a basis for revising and improving the product before it was tested in learning. To calculate the feasibility level of the validation sheet, researchers used a certain formula as follows (Amelia, 2021).

$$K = \frac{F}{N\ X\ I\ X\ R} X\ 100\%$$

Description:

K = Percentage of Product Feasibility
F = Total Respondent Answers
N = Highest Score in Questionnaire
I = Number of Questions in Questionnaire
R = Number of Respondents

The assessment of the validity of learning media consists of 5 scales, namely with the maximum expected value is 100% and the minimum value is 0%. The product is considered very feasible if the X value is more than 81%, feasible if the X value is more than 61%, quite feasible if the X value is more than 41%, less feasible if the X value is more than 21%, and very unfit if the X value is more than 0%. The average validator assessment results are then categorized based on Table 1.

Table 1. Product Feasibility Category (Ningsih & Komikesari, 2019).

Percentage	Criteria
81-100	Very Feasible
61-80	Worth
41-60	Less Feasible
21-40	Not Feasible
0-20	Very unfeasible

The implementation stage in this study was carried out by applying interactive flipbook media in learning activities in class XII SMA Baitul Arqom Jember, involving 25 students as samples. This number has met the feasibility of sample size in educational research, as stated by (Besekar et al., 2024) that a minimum sample size of 24 participants per group can provide valid results in interventional education-based research. Student response data was obtained through the distribution of questionnaires designed to measure the level of interest, ease of use, and usefulness of interactive flipbook media in the learning process. Each statement in the questionnaire uses a Likert scale, and the results are analyzed using the percentage formula to determine the proportion of the level of student response to the media developed. The formula used is as follows:

$$P = \frac{f}{n} x\ 100\%$$

Description:
P = percentage of student response scores
f = number of scores from data collection
n = total number of maximum scores

Thus, these students gave a good response to the interactive flipbook media. Based on these results, the following categories of student responses can be seen in Table 2.

Table 2. Learner Response Category (Larasati *et al*., 2022)

Percentage	Rating Scale	Description
88-100	5	Very good
76-87	4	Good
63-75	3	Simply
50-62	2	Less
0-49	1	Very Less

The normality test is carried out to determine whether the N-Gain value data is normally distributed as a prerequisite in parametric statistical testing. In this study, the N-Gain data normality test was carried out using the Kolmogorov-Smirnov (K-S) Test to ensure that the data was normally distributed before parametric statistical analysis. In this study, the data normality test was conducted using the Kolmogorov-Smirnov (K-S) Test to check whether the data distribution of N-Gain scores followed a normal distribution. The K-S test is a non-parametric statistical test that compares the empirical cumulative distribution of the sample with the assumed theoretical cumulative distribution, in this case the normal distribution (Eller & Shtembari, 2021). The statistical formula for the Kolmogorov-Smirnov test is as follows:

$$\mathrm{D} = \max |\ F_n(x) - F(x)$$

Description:
D = K-S statistical value (maximum difference between empirical and theoretical distributions or p-value).
$F_n(x)$ = Empirical cumulative distribution (proportion of sample data ≤ x).
F(x) = Theoretical normal cumulative distribution.
Max = Highest absolute difference value.

The test decision is based on the p-value with a significance level of 0.05. If the p-value > 0.05, the data is considered normally distributed and parametric statistical analysis can proceed. Conversely, if the p-value ≤ 0.05, the data is not normally distributed and non-parametric analysis needs to be performed. This reference test has been widely used in modern scientific research because of its sensitivity in detecting differences in data distribution, especially in small to medium sample sizes (Otsu & Taniguchi, 2020).

This study used a one-group pretest-posttest design, which is suitable for evaluating the effectiveness of learning media in a direct classroom context (Sylvia *et al*., 2020). To measure learning outcomes, test instruments were used that were given before and after learning to assess students' cognitive improvement. According to (Febriyanti *et al*., 2018), measuring the improvement of learning outcomes with pretest-posttest is a valid method and is often used to assess the effectiveness of interventions in the context of STEM education. tem on the pretest and posttest were arranged in the form of 15 multiple choice questions, each with five answer options (a, b, c, d, and e). The questions were developed based on indicators of competency achievement on genetic mutation material and adapted to the learning objectives that have been set. To determine the increase in learning outcomes, researchers used the N-Gain formula, according to (Hayati & Muthia, 2024) that the N-Gain formula is used to measure the effectiveness of a learning or intervention in improving student learning outcomes. The N-Gain formula is expressed as follows:

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

The N-Gain score results were divided into three categories to show how much the students' learning outcomes improved. The categories can be seen in the Table 3.

Table 3. Criteria for Normalized Gain (Sumiati *et al*., 2023)

Category	Criteria
N-Gain < 0.3	Low
0.3 < N-Gain < 0.7	Medium
N-Gain > 0.7	High

The Evaluation stage is carried out to assess the overall effectiveness and feasibility of the learning media that has been developed. Evaluation is carried out formatively, namely during the development process, and summatively after media implementation. Data obtained from the results of expert validation, pretest-posttest, and student responses were analyzed to assess the extent to which the interactive Flipbook meets learning quality standards. The assessment focused on the suitability of material content, visual design, integration of the Science Technology Society (STM) approach, and its impact on student motivation and learning outcomes. Based on the evaluation results, final revisions were made to the media so as to produce a product that is ready to be used as an innovative alternative in learning biology, especially on genetic mutation material.

RESULTS AND DISCUSSION

The development of interactive flipbook media with a Science Technology Society (STM) approach on class XII genetic mutation material to improve student learning outcomes is in accordance with the steps of the ADDIE model Research and Development research procedure, namely: Analysis, Design, Development, Implementation, and Evaluation. The following are the results and discussion of each stage:

Analysis Stage

At the analysis stage, identification of the condition of biology learning, especially genetic mutation material at MA Baitul Arqom Jember was carried out. Through interviews with teachers and distributing questionnaires to 25 students of class XII, it was found that learning so far still uses conventional methods such as lectures with the lack of interactive and contextual learning media. Students' difficulty in understanding genetic mutation material is also due to the lack of visual media that is interesting and relevant to everyday life. Therefore, interactive learning media and integrating the Science Technology Society (STM) approach are considered urgently needed to improve student understanding. The curriculum used is the

independent curriculum. In analyzing the material, the material is adjusted to the level of difficulty that students can understand, and is associated with everyday life so that learning becomes more interesting and meaningful.

Research conducted by (Irdalisa et al., 2023) states that classroom learning is often unable to present meaningful learning experiences, causing students to have difficulty understanding the material. This statement is in line with the opinion (Firmadani, 2020), which emphasizes that along with technological developments, the ability to innovate in designing a good learning environment is needed for teachers so that learning is more optimal.

Design Stage

Based on the results of the analysis, researchers designed an interactive flipbook by taking into account the learning objectives and characteristics of students. The design process includes preparing materials according to the curriculum, making storyboards, determining media layouts, and adding interactive elements such as animations, videos, and quizzes. In addition, validation instruments for material experts, media, and practitioners as well as student response questionnaires were also prepared in order to measure the feasibility and effectiveness of the media.

Development Stage

At this stage, the interactive flipbook with the Science Technology Society (STM) approach was developed using the Canva application, which was chosen for its flexibility in structuring the appearance of interactive learning media visually and functionally. Various contents in the form of text, images, animations, videos, and interactive questions are incorporated into the media. This approach allows the presentation of learning materials visually and contextually, which is relevant to students' daily lives. The study by (Syukri et al., 2024)) showed that flipbook-based e-modules with a STEM approach were effective in improving student learning outcomes. In addition, (Divia et al., 2022) found that the use of Canva in the development of electronic student worksheets can improve students' practical skills and science processes. The initial product was tested for feasibility through validation by three experts, namely media expert lecturers, biology material expert lecturers, and biology teachers. Based on the input from the validators, minor revisions were made, especially on the use of terms and visual displays to make it easier for students to understand.

After the product design process is complete, the next step is to validate the interactive flipbook media involving three parties, namely media experts, material experts, and educational practitioners. This validation aims to assess the feasibility of media in terms of visual appearance, suitability of material content, and usability in the context of learning in the classroom. The results of the validators in the form of suggestions and comments are used to make improvements or revisions so that the learning media developed can be used properly, before being tested on students. Validation is carried out using a media feasibility assessment instrument.

Interactive flipbook media validation products include media experts, material experts, and practitioner experts. The assessment criteria by the three experts are categorized as very feasible if the percentage is in the 81%-100% range. A product is considered feasible if it gets a percentage of 61%-80%, while a fairly feasible category is given for a percentage of 41%-60%. If the percentage is in the range of 21%-40%, then the product is included in the less feasible category. As for products that have a percentage below 21% are categorized as not feasible (Arikunto, 2021).

The validation results of each component by the experts are shown in the following Table. The results of validation from material experts regarding the suitability and quality of learning media content are presented in Table 4 below. This table contains scores and categories of assessment of several important aspects, such as the suitability of the material

with learning objectives, the level of ease of understanding the material, and the relevance of the material to the Science Technology Society (STM) approach.

Table 4. Material Expert Validation Assessment Results

No	Indicator	Score (%)	Category
1	Suitability of material with learning objectives	82	Very Feasible
2	Suitability of the material according to the level of student development	79	Worth
3	Clarity of material is easy to understand	80	Worth
4	The suitability of the material with the Science Technology Society (STM) approach	79	Worth
	Average	80	Worth

Based on the results of validation conducted by material experts, interactive flipbook media shows an average value of 80% with the category "Very Feasible" in terms of content and suitability with the Science Technology Society (STM) approach. Furthermore, to ensure the quality of the media from the technical and visual side, validation was carried out by media experts. The aspects assessed include visual appearance, ease of navigation, and user interactivity. The results of validation from media experts are presented in the following table:

Table 5. Media Expert Validation Analysis Results

No	Indicator	Score (%)	Category
1	Visual appearance quality (design, color, layout)	85	Very Feasible
2	Ease of navigation between pages	81	Very Feasible
3	Level of user interactivity with the media	78	Worth
	Average	82	Very Feasible

Table 5 shows that the interactive flipbook media has an attractive display quality, easy-to-understand navigation, and good interactivity. These three aspects scored 82%, which falls into the "Very Appropriate" category. This indicates that the media has been designed with attention to the comfort and convenience of users in accessing and understanding the content of the material.

In addition to validation by material and media experts, the use of media in classroom learning practices is also an important concern. Therefore, an assessment was conducted by expert practitioners who are teachers of related subjects. The assessment focused on aspects of ease of use, relevance to learning needs, and the effectiveness of the media as a teaching aid. The results of validation from expert practitioners are presented in the following table:

Table 6. Practitioner Expert Validation Results

No	Indicator	Score (%)	Category
1	Appropriateness of media use in classroom learning	82	Very Feasible
2	Ease of use of media by teachers and students	80	Very Feasible
3	Effectiveness of media in helping achieve learning objectives	81	Very Feasible

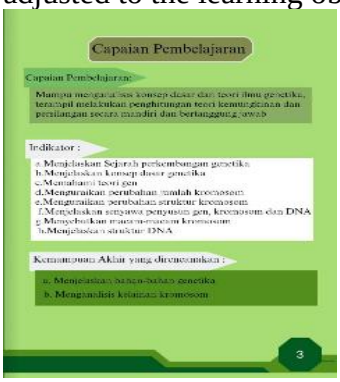
Average	81	Very Powerful

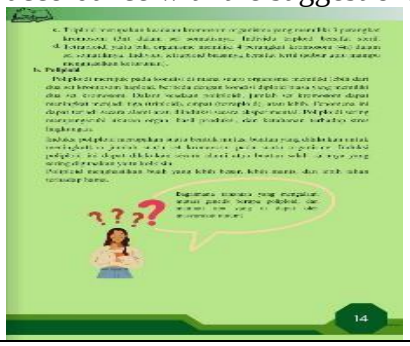
From the assessment results shown in Table 6, it can be concluded that the interactive flipbook media scored 81%, categorized as "Very Feasible" for use in learning. The high score on the usability indicator indicates that this media is practical, easy to use, and effective in supporting the teaching and learning process, especially for genetic mutation material.

Overall, validation by material experts, media experts, and practitioner experts indicates that interactive flipbooks are very feasible to use as learning media, with an average score of 81%. The media are appropriate in terms of content, appearance, interactivity, and usability in learning. This finding shows that the interactive flipbook meets the criteria for an effective and innovative medium to support the learning of genetic mutation material using the Science Technology Society (STM) approach.

After the initial validation stage, the developed learning media received several inputs from validators regarding content, visual appearance, and interactivity. To assess the effectiveness of the improvements, a comparison of validation results before and after revisions based on expert suggestions was conducted. In the "before revision" column, several aspects required improvement, including alignment of learning outcomes with objectives, suboptimal placement of learning videos, lack of supporting illustrations, sentence structures that needed simplification for clarity, and the quality of the videos. Following the recommended revisions, the media improved in completeness and coherence, which increased the validation score and made the media more suitable for implementation in learning activities.

Tablel 7. Results of suggestions and revisions from validator

Before Revision	After Revision
In this section, the learning outcomes are adjusted to the learning objectives. 	This section has been adapted to the learning objectives in accordance with the instructions given. 
In this section, the learning video is made into a separate page 	in thisn the video has been made into its own page according to the suggestions given section 

Before Revision	After Revision
In this section, add an example image 	In this section, an example image has been added 
In this section rearrange the sentences in the column 	In this section, the sentences in the column have been arranged in accordance with the suggestions given. 

Implementationl Stage

This implementation stage aims to determine the effectiveness of the interactive flipbook media based on the Science Technology Society (STM) approach in improving students' learning outcomes on genetic mutation material. To assess learning gains, pretests and posttests were administered using an instrument of 20 multiple-choice questions. The data were analyzed using the N-Gain score to measure the level of improvement in learning outcomes, and a normality test was performed to verify that the N-Gain data were normally distributed. The normality test used the Kolmogorov–Smirnov procedure as follows:

$$D_{table} = \frac{1.36}{\sqrt{n}} + \frac{1.36}{\sqrt{25}} = \quad \frac{1.36}{5} = \quad 0.272$$

The sample size was n=25. The calculation yielded Dcount= 0.168, which is less than Dtable=0.272; therefore, the N-Gain data are normally distributed. Based on this Kolmogorov–Smirnov normality result, further analysis can proceed to compute the N-Gain to determine the increase in students' learning outcomes after applying the interactive flipbook media based on the Science–Technology–Society (STM) approach. The N-Gain was calculated using the formula from Hake (1999). The following table presents the N-Gain calculations based on the pretest and posttest scores of 25 students.

Table 8. Student N-Gain Calculation Results

No	Student	Pretest	Posttest	N-Gain	Category
1	PPZ	40	55	0.75	High
2	MS	45	99	0.78	High
3	DDA	38	80	0.68	Medium
4	NKL	42	86	0.76	High
5	SNA	50	90	0.80	High

No	Student	Pretest	Posttest	N-Gain	Category
6	FW	35	78	0.65	Medium
7	OTA	48	92	0.77	High
8	CNI	44	84	0.71	High
9	MUS	39	82	0.72	High
10	RAR	41	83	0.71	High
11	ADP	36	79	0.66	Medium
12	MY	47	89	0.78	High
13	BA	43	87	0.76	High
14	RMS	37	80	0.69	Medium
15	SM	49	90	0.78	High
16	SW	34	75	0.64	Medium
17	HW	46	88	0.77	High
18	SH	40	82	0.70	High
19	MAJ	38	79	0.67	Medium
20	FF	45	85	0.73	High
21	AMA	41	84	0.72	High
22	MH	43	86	0.74	High
23	MD	36	78	0.65	Medium
24	MSB	48	91	0.78	High
25	MJ	42	87	0.78	High
Average				**0.76**	**High**

Based on the data, 68% of students fell into the High N-Gain category, and the mean N-Gain was 0.76 (High). These results suggest that the interactive flipbook media using the Science–Technology–Society (STM) approach improved learning outcomes in this sample. Prior studies report similar patterns: Wulan et al. (2025) found that interactive flipbook media can improve student outcomes by presenting material in an engaging, interactive format, and Hadawiyah et al. (2019) showed that the STM approach yielded higher posttest scores on environmental pollution topics for grade VII students than conventional instruction.

After validation and revisions based on validator feedback, the interactive flipbook media were implemented with 25 grade XII students at Baitul Arqom Jember High School to evaluate effectiveness on genetic mutation content. The study used a One-Group Pretest–Posttest design with 20 multiple-choice items to measure concept mastery before and after using the media. In addition to learning outcomes, student responses were collected; students reported positive assessments regarding engagement, motivation, and ease of independent use. A summary of student responses is provided in the accompanying Table 10.

Tabel 10. Hasil Respon Siswa

No	Indicator	Score (%)	Category
1	Interactive flipbook media creates a fun and not boring learning atmosphere	85	Good
2	Media interactivity helps increase learning motivation	83	Good
3	Interactive flipbooks can be used as independent learning media by students	88	Good
4	The visual appearance of the flipbook is interesting and makes it easy to understand the material	90	Very good

No	Indicator	Score (%)	Category
5	Flipbook media is easy to use and accessible to various places	86	Good
6	Flipbook media visualizes social issues related to the development of science and technology.	88	Good
	Average	**87**	Good

The results of the analysis of student responses to the use of interactive flipbook media show that this media obtained an overall positive assessment with an average score of 87%, which is classified in the good category. The response to the indicator of a pleasant and not boring learning atmosphere scored 85%, indicating that this media is able to create an interesting learning environment for students. The interactivity aspect of the media also scored 83%, indicating that the interactive flipbook media was able to significantly increase students' learning motivation. In addition, this media is considered effective as an independent learning tool with a score of 88%, which shows its ability to support students' independence in the learning process.

The visual appearance of the media obtained the highest score of 90%, in the very good category, which underlines that the visual design of the flipbook is very attractive and facilitates understanding of the material. The ease of use and accessibility of flipbook media scored 86%, indicating that this media can be used flexibly in various places. Furthermore, this media is also able to visualize social issues related to the development of science and technology with a score of 88%, strengthening the relevance of learning materials to the social context. Overall, student responses indicate that interactive flipbook media is feasible as an effective and interesting learning media.

Evaluation Stage

The evaluation stage is an important component of the ADDIE model that serves to assess the quality and success of the developed learning media. Evaluation is conducted to measure the effectiveness, efficiency, and attractiveness of the media, as well as to ensure that it meets user needs and expectations (Wulan et al., 2025). The process involved validators—material experts, media experts, and practitioners—as well as end users (students). Validators assessed content, visual appearance, ease of navigation, and interactivity using standardized validation instruments, while learners' responses were collected through questionnaires to gauge acceptance, motivation, and ease of use in the learning process.

In addition to qualitative data from validation and learner responses, a quantitative evaluation was conducted through trials using a One-Group Pretest–Posttest design. Multiple-choice instruments were used to measure gains in students' conceptual understanding of genetic mutation material before and after using the media. Analysis of learning outcomes using N-Gain values indicates that the N-Gain data are normally distributed, with a mean of 0.76 in the high category, suggesting that the interactive flipbook media improved students' learning outcomes.

Media validation results show an average score of 81%, indicating that the media are classified as very feasible to use. Student responses were also positive, with an average score of 87%, indicating increased learning motivation, a pleasant learning experience, and ease of use. Based on these evaluation results, the interactive flipbook media are feasible and effective as a learning medium and provide a strong basis for further development and improvement.

CONCLUSION

The development of interactive flipbook media using the Science–Technology–Society (STM) approach for Grade XII genetic mutation material followed the ADDIE stages: analysis, design, development, implementation, and evaluation. Validation scores were 80% from

material experts, 82% from media experts, and 81% from practitioner experts, with an overall average of 81% categorized as "very feasible." Implementation yielded an average N-Gain of 0.76 (high category). Student responses averaged 87%, indicating the media supported motivation, engagement, and understanding, and offered an easy-to-use learning experience.

However, the study used a one-group pretest–posttest design without a control group. To improve validity and generalizability, further trials should include a control group and span different school contexts and education levels. This would test the consistency of the media's effectiveness in varied conditions and strengthen empirical evidence for STM-based interactive flipbook media.

RECOMMENDATION

Based on the results of this study, it is recommended that researchers and teachers use interactive flipbook media based on the Science Technology Society (STM) approach as one of the effective and innovative learning media options, especially for genetic mutation material. Future researchers are expected to conduct trials with a more rigorous design, such as using a control group and trying the media in various schools. control group and try the media in various schools, so that the results are more valid and can be used in various learning conditions. Media development also needs to be continued by adding interactive features and improving the visual appearance and content of the material so that the media is more attractive and in accordance with the needs of students. In addition, teachers are expected to utilize this media maximally to increase student motivation and learning outcomes, as well as support more contextual and relevant learning according to the STM approach.

ACKNOWLEDGMENT

The authors would like to express their deepest gratitude to all those who have provided support and assistance during the process of preparing this research. Special thanks go to the two supervisors for their guidance, direction, and motivation which are very meaningful for the smoothness and success of this research. In addition, the author also appreciates family and friends who always provide moral support and enthusiasm so that the author can complete this research well.

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