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Food Security Awareness Education through Animation Video to Enhance Students' Learning Outcomes in Biotechnology Lesson

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Abstract

Tissue culture is a biotechnology topic in junior high school science education that is often perceived as complex and abstract, resulting in low student comprehension and a lack of understanding regarding its connection to food security issues. This study aims to develop an animated video that integrates the concepts of tissue culture and food security in a valid, practical, and potentially effective in enhance food security awareness and students' cognitive learning outcomes. The study used the Research and Development method with a modified 4D, limited to three stages: define, design, and develop. Media experts and content experts validated the product, then tested on 20 students using a one-group pretest-posttest design. Validation results indicated that the media was highly valid, scoring 100% from media experts and 95.14% from content experts. Student responses indicated that the media was highly practical, scoring 81.18%. Statistical analysis revealed a significant improvement in food security awareness (N-Gain = 0.37; Cohen's d = 1.23) and cognitive learning outcomes (N-Gain = 0.77; Cohen's d = 0.88), indicating the media's influence on these two variables. This research contributes to the integration of food security education into biotechnology teaching through animation-based media.

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INTRODUCTION

Indonesia's growing population, which increases every year, poses a serious challenge to meeting national food needs. Data from the Central Statistics Agency (BPS) indicates that Indonesia's population will reach 284 million by 2025 and is projected to continue growing. This situation not only increases food demand in quantitative terms but also places greater pressure on the food production system, which still faces various constraints, such as land conversion, climate change, and food distribution inequality. This indicates that efforts to ensure food security must be comprehensive and holistic. Food security is not limited to food availability but also encompasses the interrelated aspects of access, utilization, and food stability (FAO, 2018). Therefore, efforts to ensure food security must be sufficient not only in quantity but also in quality, safety, and sustainability. The implementation of national food security aligns with the commitments of the global sustainability agenda, namely the Sustainable Development Goals (SDGs), particularly Goal 2 on Zero Hunger, which aims to end hunger, achieve food security with improved nutrition, and support sustainable agriculture (Lesmana et al., 2024).

To support these efforts, a comprehensive approach is needed that involves various stakeholders. The education sector plays a strategic role in shaping the younger generation's awareness and understanding of food security issues. Education serves not only as a means of transferring knowledge but also as a means of shaping attitudes and fostering social responsibility. Fahmi et al. (2018) state that food security should be taught from an early age, beginning with foundational knowledge about food, which is expected to serve as the basis for developing concern and engaging in practical actions in daily life. However, several studies indicate that the younger generation's awareness of food security issues remains relatively low, and their knowledge of these issues is also limited, potentially due to the insufficient integration of these issues into the learning process (Fahmi et al., 2018; Widiyastomo, 2022). This situation indicates a gap between the urgency of food security issues and their implications in formal education. In fact, integrating real-world contexts into learning concepts has been shown to enhance conceptual understanding while fostering students' concern for global issues (Bern & Erickson, 2001).

The integration of food security concepts into the learning process can be achieved through the Natural Sciences (IPA) subject, particularly in the biotechnology material. Modern biotechnology, such as tissue culture, holds great potential to increase crop production through innovations in in vitro plant propagation, enabling the production of high-quality seedlings in large quantities with uniform characteristics, independent of environmental conditions (Ellya et al., 2024). Thus, understanding the concept of tissue culture is relevant in the context of food security as an alternative solution. However, teaching tissue culture still faces various challenges. The complex and abstract nature of the subject matter, coupled with a lack of adequate learning resources, makes it difficult for students to grasp the concepts. Students tend to be more familiar with conventional biotechnology, such as tempeh and tofu, which are commonly encountered in daily life; consequently, their understanding of tissue culture concepts remains less than optimal.

Several studies have shown that the limitations of conventional teaching methods, which lack visual representations of concepts, also pose a barrier to understanding tissue culture material (Zetkas et al., 2016; Harahap et al., 2020). Presenting material limited to basic concepts and tissue culture techniques limits students' ability to fully understand the concepts, particularly their real-world applications (Hartini et al., 2019). Additionally, inadequate learning resources affect students' conceptual understanding; students are more easily influenced by misconceptions without reliable information sources (Harahap et al., 2020). These conditions contribute to low student interest and participation in the learning process, which ultimately results in suboptimal cognitive learning outcomes (Ardianti et al., 2025). Furthermore, instruction still relies heavily on conventional media to present material, causing students to become easily bored because the learning process is monotonous and fails to capture their attention. The results of the analysis and observations conducted also revealed challenges in the learning process for tissue culture material. The teaching media used

during lessons were limited to traditional PowerPoint presentations, with no interaction with the students. Students' learning resources consist of science textbooks, with the material presented limited to the tissue culture stage. This results in learning that tends to be monotonous; students quickly become bored and lose enthusiasm for participating in learning activities, leading to suboptimal learning outcomes. Additionally, it was noted that the science material provided to students remains insufficiently detailed due to the complexity and volume of material that must be covered, while the time allocated for learning is limited.

Given the current issues, it is necessary to develop learning media innovations that present material in a more interesting, interactive, and contextual way. Media that can visualize abstract concepts in concrete terms facilitate students' understanding of the material. One alternative is an animated video, which can be dynamically integrated with visual and audio elements, making it easier for students to understand concepts, especially abstract ones (Mayer, 2014). Several studies have also shown that using animated videos as a learning medium can improve learning outcomes, motivation, and student participation (Ardianti et al., 2025; Mahbub et al., 2016).

However, most research on the use of animated videos has focused on improving students' cognitive outcomes and has not explicitly integrated global issues, such as food security, into the context. In biotechnology education, research on tissue culture has largely involved the development of learning resources such as virtual laboratories or encyclopedias as learning materials (Hartini et al., 2019; Harahap et al., 2020). In addition, research in biotechnology that uses a contextual approach integrating global issues to build student awareness remains rare. This indicates a gap between optimizing students' understanding of scientific concepts and their awareness of real-world problems. Research integrating food security awareness into biotechnology learning through animated video media remains very limited. Therefore, this study was conducted to develop an animated video on tissue culture, designed not only to improve students' cognitive learning outcomes but also to integrate food security concepts to encourage food security awareness among students.

Animated videos are a viable alternative because they present information in a visual, dynamic way. The use of animated videos in science education has been shown to significantly improve student learning outcomes by combining text with motion pictures, making abstract concepts easier for students to understand. Additionally, animated media can also increase student motivation and participation in the learning process (Ardianti et al., 2025). Through the developed animated media, it is hoped that students will not only better understand tissue culture material but also improve their awareness of the importance of tissue culture in supporting national food security. A comprehensive understanding of food security is the first step in raising students' awareness of it (Stevens et al., 2020). A solid understanding of food security will foster a caring attitude and a sense of responsibility that can be applied in real-world practice. This study aims to develop valid and practical animated learning media on tissue culture, improve students' cognitive learning outcomes on tissue culture, and enhance students' awareness of food security by integrating these concepts into the learning media. The completion of this research contributes to science through a learning approach that integrates an understanding of biotechnology concepts with global issues, and produces animated videos that not only serve as a learning medium supporting cognitive learning outcomes but also raise students' awareness.

METHODS

Participants

The data were collected from 20 ninth-grade students at one junior high school in Semarang, Indonesia, who consented to participate and served as the study sample. Purposive sampling was used, with the criteria being ninth-grade students who had not yet been taught the Biotechnology lesson, particularly the plant tissue culture material.

Research Design

This study applied the 4D model (Thiagarajan et al., 1974) in a limited manner across three stages: Define, Design, and Develop, omitting the Disseminate stage. The limitation in the development stage was due to constraints on time,

cost, and the research sample. The media trial was conducted on a small scale using a one-group pretest-posttest design, without a control group due to time limitations, lack of access to a homogeneous parallel class, and the scope of the research. The effectiveness of the media intervention was assessed through an effect size analysis (Cohen's d) to measure changes objectively.

The define stage is the initial stage for identifying and defining needs within the learning process and gathering various information related to the product to be developed. The Define stage involves observations of science learning processes and interviews with science teachers and students to analyze needs for product development. Additionally, an analysis of previous research on the development of tissue culture materials and the integration of food security concepts into learning was conducted. The purpose of the needs analysis and concept analysis is to provide an initial overview as a basis for product development, ensuring the resulting product aligns with the needs and conditions of actual learning practices.

The design stage aims to develop the educational media. The design phase includes media selection, material design, and media design. Media selection involves identifying educational media that align with the needs analysis and results from the define stage. The animation media is created using the Pippit AI platform by composing prompts that are then generated. Content design involves formulating learning objectives and integrating concepts of tissue culture and food security into the developed media. This stage also includes creating a storyboard to outline the media's flow and developing research instruments for media validation and pilot testing.

The develop stage aims to produce the designed instructional media. This stage includes media development, expert validation, and media testing. Media and subject matter experts conduct expert validation of the developed instructional media before pilot testing; the validation results will inform product revisions. The validated and revised product is then pilot-tested on a small scale to measure the media's effectiveness. The effectiveness of the media is assessed based on food security awareness and students' cognitive learning outcomes.

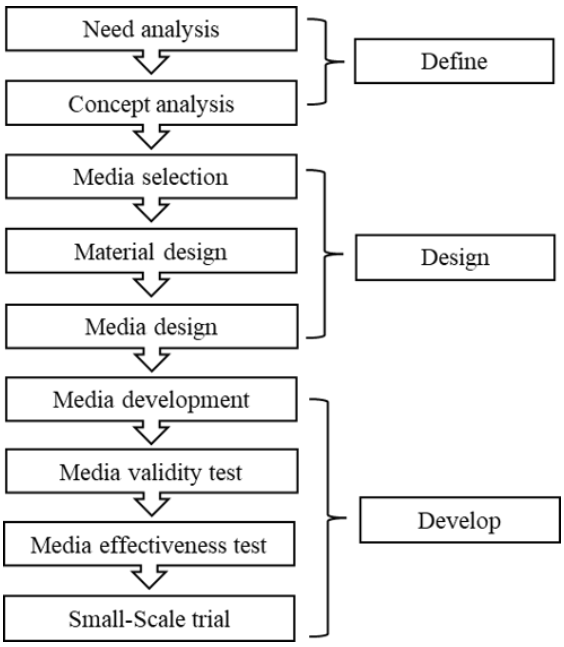


Figure 1. The stages of media development using the modified 4D model are limited to three stages (Antula et al., 2024)

Research Instrument and Validation

The data in this study were collected through pretest and posttest administrations of a questionnaire measuring food security awareness and a written test assessing student learning outcomes. Student responses to the developed media were measured using a questionnaire to assess the media's practicality from users' perspectives.

The food security awareness questionnaire consisted of 15 statements covering three aspects of food security awareness: 6 cognitive, 4 dispositional, and 5 active. The learning outcomes are measured through a written test comprising 15 multiple-choice questions that assess students' cognitive abilities related to tissue culture material. The research instruments used in this study are presented in Table 1.

Table 1. The research instrument of this study

Indicator	Method of data collection	Instrument	Analysis
Media validity	Questionnaire	1. Media validation questionnaire sheet by media experts 2. Material validation questionnaire sheet by material experts	Quantitative description
Effectiveness of animation video:			
Food Security Awareness	Questionnaire (before and after)	Statement questionnaire sheet to measure food security awareness	Statistical test
	Written test (pretest-posttest)	Multiple choice	Statistical test
Learning outcomes			
Practicality of media	Questionnaire	Questionnaire sheet on students' response to media	Quantitative description

Data Analysis

Before the media is tested, a validity test is conducted to ensure that the medium and content are suitable. The validity and practicality of the media were analyzed descriptively and quantitatively, measured using the formula:

$$P = \frac{f}{N} \times 100\% \quad \text{..... (1)}$$

P = final score
f = score obtained
N = maximum score

The results of the media validity test calculations are then interpreted in Table 2 (Antula et al., 2024).

Table 2. Media Eligibility Criteria

Percentage of Presentation Interval	Media Validity Criteria	Media Practicality Criteria
81% - 100%	Highly valid	Very Good
61% - 80%	Valid	Good
41% - 60%	Sufficiently valid	Enough
21% - 40%	Less than valid	Low
0% - 20%	Not valid	Very low

The trial data were analyzed using validity and reliability tests to assess the suitability of the instruments. Validity was analyzed using Pearson's Product-Moment correlation, the instrument was considered valid if the calculated r > the table r at a 5% significance level. The reliability of the instrument was analyzed using Cronbach's Alpha to assess its consistency. The instrument was considered reliable if the Cronbach's Alpha value was ≥ 0.70.

Before conducting the hypothesis test, a normality test was first performed as a requirement for parametric analysis. The hypothesis test was conducted using a paired-sample t-test for normally distributed data and a Wilcoxon test for non-normally distributed data. Next, an effect size test and an N-Gain test were conducted to determine the magnitude of the effect and the increase in food security awareness and students' learning outcomes after using the media. The effect size is calculated using Cohen's d formula as follows:

$$d = \frac{\bar{X}post - \bar{X}pre}{Sp} \quad \text{..... (2)}$$

d = effect size score
$\bar{X}post$ = posttest mean
$\bar{X}pre$ = pretest mean
Sp = combined standard deviation

The calculation result were then categorized based on the criteria in Table 3

Table 3. Effect Size Category

Effect size score	Category
0.2 – 0.5	Small effect
0.5 – 0.8	Medium Effect
> 0.8	High effect

In the media effectiveness test, statistical data analysis was performed by comparing students' pretest and posttest scores. The analysis used the N-Gain test to assess media effectiveness, with levels ranging from low to high. The formula for the n-gain test is shown below:

$$g = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score} \quad \text{..... (3)}$$

The calculation results were then categorized based on the criteria in Table 4 (Hake, 1999).

Table 4. N-Gain Category

N-Gain Score	Category
$0.70 \leq g \leq 100$	High
$0.30 \leq g < 0.70$	Moderate
$0.00 < g < 0.30$	Low
g= 0.00	No increase

RESULTS AND DISCUSSION

The study was conducted using the Research and Development method with a 4D model limited to only three stages: define, design, and development. The study began with the development of a tissue culture animation video, which was then validated by material and media experts. After revisions were made based on the experts' suggestions and the animation video was validated, a small-scale trial was conducted with 20 ninth-grade students as research subjects. The small-scale trial was conducted to measure the practicality and effectiveness of the animated video. The practicality of the animated video was assessed using student responses and the 11 indicators listed in Table 9. At the same time, the media's effectiveness was measured using food security awareness scores and students' cognitive learning outcomes. Measurement of food security awareness was conducted by considering three aspects: cognitive, dispositional, and active, as detailed in the flow of the animated video in Table 6. Student learning outcomes were measured through a written multiple-choice test on tissue culture material. The integration of tissue culture material into the animated video is detailed in Table 6.

Stages of Animated Video Development

The define stage is the basic stage of development, focused on conducting needs and concept analyses. This stage was conducted based on a review of previous studies related to the research and on direct observations at school. At this stage, an initial analysis was conducted based on a review of previous studies on the research and on direct observations at the school.

Table 5. Literature review for need and concept analyses

No	Title	Objectives	Results	Reference
1.	The effect of diabetes education given to children with type 1 diabetes mellitus with digital games and video animation on quality of life	The aim of the study was to examine the effects of diabetes education, using a digital game and video animation, on quality of life and metabolic control in children with Type 1 Diabetes Mellitus.	The results of the study indicate a significant improvement in children's quality of life, as indicated by an increase in the total quality-of-life score. This suggests that the use of animated videos combined with interactive elements is effective in enhancing participants' understanding and engagement.	(Tinmaz & Altunda, 2025)

No	Title	Objectives	Results	Reference
2.	The Effect of Blended Learning on Students' Learning Achievement and Science Process Skills in Plant Tissue Culture Course	The purpose of this research was to know the effect of blended learning strategy on learning achievement and science process skills of students in plant tissue culture	The application of blended learning has been proven to improve learning outcomes and science process skills. Difficulties in learning tissue culture material can be minimized by applying this learning strategy. Research shows that the integration of technology in tissue culture learning has the potential to improve learning effectiveness by helping students understand complex tissue culture material.	(Harahap et al., 2019)
3.	Development of Encyclopedia of Plant Propagation Through Tissue Culture as Additional Learning Resource for High School Students	The purpose of this study is to determine the feasibility of an encyclopedia on plant propagation through tissue culture that has been validated by material experts, media experts, and instructional design experts.	Students' lack of understanding of tissue culture material is due to the lack of available learning resources. This can lead to misconceptions about tissue culture material, resulting in low student achievement in this subject. The development of a tissue culture encyclopedia has proven to be a useful learning resource for students, facilitating their understanding of the basic concepts of tissue culture and avoiding misconceptions.	(Harahap et al., 2020)
4.	The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools	This study aims to develop a learning innovation that can enhance the Higher Order Thinking Skills (HOTS) of junior high school students in Thailand	Effectively designed instructional innovations can enhance students' Higher Order Thinking Skills (HOTS), as evidenced by improved skill scores following the implementation of such approaches. The integration of animated videos, real-life problem scenarios, and collaborative activities between students and teachers has been proven to be a valid and effective method for enhancing higher-order thinking skills among middle school students.	(Kwangmuang et al., 2021)
5.	The Effects of Science-On-Web Learning Media on Junior High School Students' Learning Independency Levels and Learning Outcomes	This research aimed to examine the effects of science-on-web learning media on grade 8 students' learning independency levels and learning outcomes of the excretion system topic.	The use of Science on Web learning media can influence junior high school students' learning independence and learning outcomes. Science on Web, which includes animations and visual objects, can help students understand the excretory system. The results show that web-based/animated media are effective in improving students' learning outcomes in science learning, although the research is still limited to the excretory system.	(Ikhsan et al., 2019)

No	Title	Objectives	Results	Reference
6.	Development of Audio-Visual Animation-Based Learning Media in Food Security Research Results	Research has been conducted to develop educational materials using animated audiovisual content to explain and disseminate information on the results of food security research.	The results of research on food security are presented through audio-visual animation learning media. The audio-visual animation media developed is considered to be able to present research results in detail, is well received, and is considered more interesting and less monotonous. The visualization is presented in an attractive manner and does not take long to view. This media makes it easier for students to digest the material presented and is practical for online use or through YouTube content to disseminate research results to a wider audience.	(Gumelar et al., 2020)
7.	Raising awareness about food security using a massive open online course	This study aims to enhance public understanding of the complex issue of food security through an eight-week massive open online course (MOOC) on an e-learning platform.	Efforts to raise public food security awareness were carried out in the study by holding a Massive Open Online Course (MOOC). The study showed that digital technology-based learning can be an effective means of expanding knowledge and increasing public understanding of food security issues. The presentation of food security issues includes information on food security challenges, food production systems, and the relationship between agriculture, the environment, and sustainability. The use of technology-based learning media in research not only helps to improve concept understanding but also raises awareness of important issues related to food security.	(Stevens et al., 2020)
8.	Food Security Policy and Community Food Literacy (Research Study on Food Literacy Supporting Food Security in Semarang City)	The aim of this study on food security and the importance of public food literacy is to describe food security in the City of Semarang based on regional planning documents and to examine whether food security and nutrition policies have been implemented in	Food literacy is important in supporting food security. Research shows that the level of public understanding of food availability, access, and utilization must be improved because it plays an important role in sustainable food security. Efforts to improve food literacy can be carried out through various means, such as public education, government policy support, and stakeholder involvement. The importance of food literacy needs to be integrated into the education or life skills curriculum and introduced from an early age.	(Rahmad Purwanto W, 2022)

No	Title	Objectives	Results	Reference
		accordance with the authority of the local government.		
9.	Raising Awareness of Environmental Crisis Caused by Textile Waste by Using 2-Dimentional Animation	This study aims to explore the potensial of two-dimensional (2D) animation as an effective media for raising awareness and promoting sustainable practices in the textile consumption.	The research utilized two-dimensional animation as a visual communication media to raise public awareness of environmental issues. The animation was developed as a form of visual communication and storytelling so that it could present environmental issues clearly, gradually, and interestingly. The results of the study show that the use of two-dimensional animation has a significant positive effect on increasing environmental awareness, as demonstrated by an increase in understanding, empathy, and willingness to adopt behaviors that support sustainability. This shows that animation can be an effective educational tool for communicating complex issues and encouraging sustainable practices.	(Mara, 2023)
10.	Contextual Teaching and Learning in Learning Environmental Pollution: The Effect on Student Learning Outcomes	This study aims to determine the effect of CTL on improving student learning outcomes in environmental pollution during the pandemic.	The Contextual Teaching and Learning (CTL) approach in science education on environmental pollution can improve student learning outcomes and increase student activity during the learning process. The concept of learning that is linked to real-world problems in the surrounding environment creates meaningful learning for students. These findings indicate that integrating contextual issues into science learning can make learning more meaningful, increase student engagement, and help students understand science concepts more easily.	(Welerubun et al., 2022)

Based on the literature review, tissue culture is a biotechnology topic that is abstract, complex, and difficult to observe directly, leading many students to struggle to understand its concepts, procedures, and benefits. The difficulties are also influenced by the limited availability of learning resources, which can lead to misconceptions among students (Harahap et al., 2020). Several studies indicate that the use of technology-based learning, such as blended learning, web-based media, and animated videos, can help students visualize abstract concepts and improve their learning outcomes (Stevens et al., 2020; Gumelar et al., 2020). In addition, integrating contextual issues, such as food security, into science learning is important for enhancing students' understanding and awareness of real-world problems. Therefore, the development of animation-based learning media that integrate tissue culture concepts with food security issues is needed to facilitate students' understanding and

make learning more contextual and meaningful. Based on observations at school, the use of media and science learning resources remained limited. Limited textbook resources can limit students' understanding of the overall concept, especially in complex, abstract science material that requires visualization. Teachers also occasionally use PowerPoint to deliver material, but the slides are traditional and lack interactivity. This causes students to quickly become bored and uninterested in learning due to the monotony of learning resources.

The design stage is the media planning stage, which involves preparing scripts and video guidelines for production using Pippit AI. The media was created using Pippit AI, an Artificial Intelligence (AI) -based platform that generates video prompts. This platform can produce one-minute videos for each generation process. The video script integrates the concepts of tissue culture and food security, aligning with learning objectives and aspects of food security awareness. The media was designed with consideration for language, content, and appearance to ensure it remains consistent with the research objectives and attracts students. The design of the concept integration in the developed animated media is presented in Table 6.

Table 6. A script for an animated video about tissue culture that integrates the concepts of plant tissue culture and food security awareness

Video Flow	Plant Tissue Culture Video Content	Food Security Awareness Aspects Integrated in the Video (Sánchez & Lafuente, 2010)
Opening	• An introduction to global and national food security issues. • Emphasizing the importance of collective awareness to maintain food security. • Conveying that modern biotechnology, especially tissue culture, is one solution. • An initial introduction to what tissue culture is in general. • An initial invitation to listen and understand the role of the younger generation.	Cognitive (Knowledge and Understanding): Understanding food security issues and the role of technology. Dispositional (Attitude): Arouses curiosity and a desire to contribute to finding solutions to existing problems.
Core Content	• Explanation of the stages of tissue culture in rice plants (explants, media, callus, regeneration). • Explanation of the advantages of tissue culture: fast results, large quantities, superior quality, and inheritance of parental characteristics. • Explanation of how tissue culture supports food security: production efficiency, pest/climate resistance, variety improvement. • Examples of farmers who apply agricultural modernization with tissue culture technology. • An invitation to the younger generation to play an active role in advancing agriculture with a technological approach.	Cognitive (Knowledge and Understanding): Explain the benefits of tissue culture in increasing food production. Dispositional (Attitude): Demonstrates empathy and concern for farmers' challenges and the importance of innovation. Active (Action and Participation): A concrete invitation to play a role in agricultural modernization

Video Flow	Plant Tissue Culture Video Content	Food Security Awareness Aspects Integrated in the Video (Sánchez & Lafuente, 2010)
Closing	Recapitulating the role of tissue culture as a biotechnology solution that supports food security efforts Conveying an inspiring message that every individual has a role and responsibility in maintaining food availability for the future. Call to contribute: "What role can I play in supporting national food security?"	Active (Action and Participation): Invitation to students to commit to actively participating in supporting food security efforts, either through agricultural activities or other efforts. Dispositional (Attitude): Attitudes supporting food security by developing responsibility and hope.

Figure 2. Animation video section preview (a) Opening; (b) Core Content; (c) Closing

The development stage is the final stage in the media development process. The video clips generated from the prompt were further developed in the CapCut application. The media creation was finalized by combining all video clips into a single animated video lasting 9 minutes 20 seconds, which was then edited to include audio and explanatory text using the CapCut application. The animated media begins with the issue of food security, a national and global problem, to attract students' attention, encourage critical thinking, and spark curiosity. The video content section presents the stages of tissue culture in detail, with visualizations of each stage to help students understand the concept. The video's end invites students to participate in food security efforts. The video section preview is presented in Figure 2.

In this stage, the developed animated video was assessed for feasibility to determine its validity and suitability for implementation in a small-scale trial. Then, a small-scale trial was conducted to evaluate the media's practicality based on user feedback and to examine its effectiveness in improving food security awareness and students' cognitive learning outcomes.

Validity test

The validity of the developed media was assessed by media experts and content experts. The validation results showed that the tissue culture animation video received a 100% score from media experts, placing it in the "highly valid" category. Meanwhile, the content validation results yielded a score of 95.14%, which also falls within the "highly valid" category. This indicates that the media have met the feasibility standards for both media and content, with details provided in Table 7 and Table 8. The high level of media validity indicates that the developed media can visualize the concept of tissue culture and integrate it with food security through an engaging visual format and abstract content. Minor revisions were made to the content based on feedback from the validators, including adjustments to audio intonation to improve communication quality and revisions to text elements in certain sections that still required refinement.

Table 7. Media Expert Validation Results

No	Aspect	Percentage (%)	Decision
1.	Graphic	100	Highly valid
2.	Effectiveness	100	Highly valid
3.	Quality	100	Highly valid
Average		100	Highly valid

Table 8. Results of Material Expert Validation

No	Aspect	Percentage (%)	Decision
1.	Contents	94.44	Highly valid
2.	Language Eligibility	95.83	Highly valid
Average		95.14	Highly valid

Practicality Test

After conducting validity tests and revising the media based on validator feedback, the media was then tested on a small scale, in part to assess its practicality. The evaluation was based on responses from 20 students regarding ease of use, effectiveness, and the benefits of the media for users. The average practicality score was 81.18%, which falls into the "very good" category, indicating that students could use the animated video easily without encountering significant obstacles. Gumelar et al., (2020) also states that animated media can convey material in an engaging way, stimulate thinking and attention, and encourage the learning process among students. An engaging and systematic combination of visuals and audio can reduce the complexity of tissue culture material and increase students' curiosity. Students' responses regarding the effectiveness and benefits of the media also indicate that the video is not only visually appealing but also aids in understanding the integration of tissue culture with food security. The "very good" practicality rating confirms that the media is suitable for users' needs and has the potential for application in biotechnology education. The detailed results of the media practicality test are presented in Table 9.

Table 9. Results of media practicality test

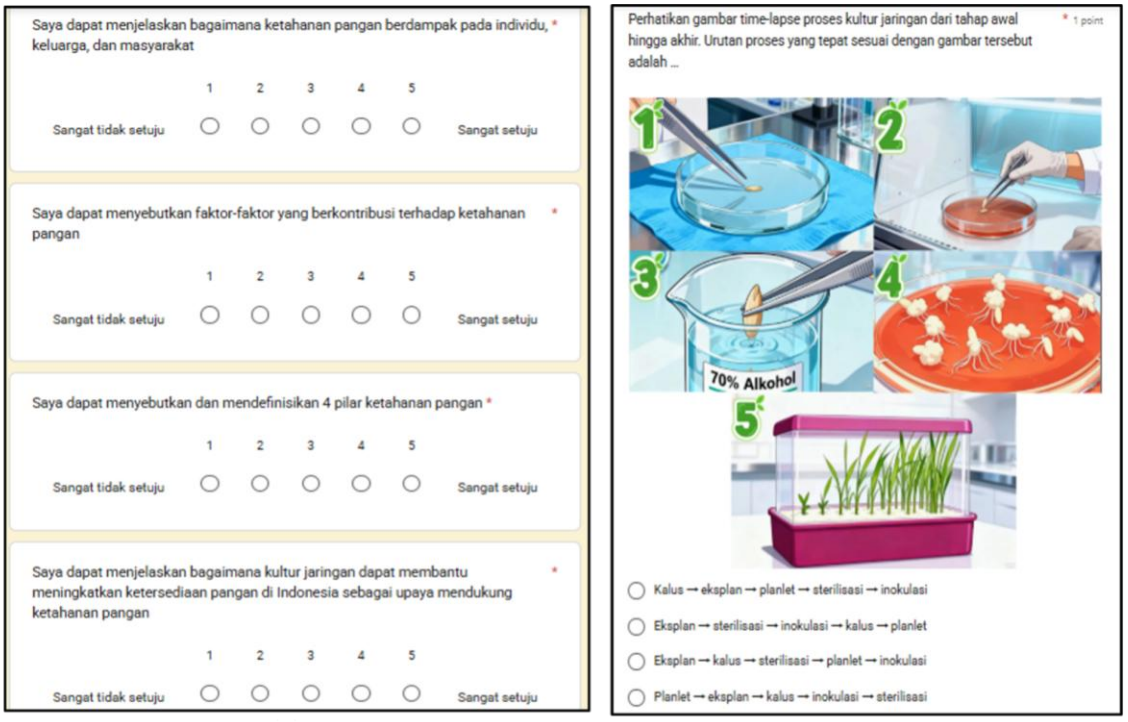
No	Indicator	Percentage (%)
1.	The use of text in videos is easy to read	84
2.	Interesting animated videos to watch	84
3.	Animated visuals in videos are interesting for learning the material	80
4.	Suitability of images and animations to the material	81
5.	Use of language in accordance with the General Guidelines for Indonesian Spelling (PUEBI)	81
6.	Communicative and persuasive language	77
7.	Easy to understand media	82
8.	Understanding the role of tissue culture in supporting food security	79
9.	The media makes it easier to understand the material	81
10.	Suitability of media in integrating tissue culture material with food security	83
11.	Ease of recognizing different illustrations of the same concept	81
Average		81.18

Effectiveness Test

The media effectiveness test aimed to measure the impact of the tissue culture animation on students' food security awareness and cognitive learning outcomes. The effectiveness of the tissue culture animation video was measured through a small-scale trial as an initial overview for broader learning. The study used a one-group pretest-posttest design in a single class. The lesson began with an introduction, followed by the pretest, the treatment involving watching the 9-minute 20-second animated video together, a concept discussion after the screening, a replay of the video, and the posttest. At the end of the lesson, students redrew the stages of tissue culture to assess their ability to represent the concept.

Measurements of food security awareness were analyzed across three aspects adapted from Sanchez & Lafuente (2010): cognitive, dispositional, and active. These three aspects were deemed capable of representing students' awareness, beginning with the cognitive aspect as the foundational basis of awareness through existing knowledge. The dispositional aspect fosters internal motivation to drive behavioral change, while the active aspect demonstrates personal readiness to take concrete actions. A similar approach has been widely used in sustainability research. By incorporating the cognitive, dispositional, and active aspects, efforts to raise awareness become comprehensive, encompassing not only understanding but also attitudes and readiness to implement concrete

actions in support of sustainability (Alissa, 2022; Sahadeo et al., 2025). These three aspects of food security awareness are detailed in Table 11. They were measured using a questionnaire with a 1-5 Likert scale. Based on the results of the trial, the instrument's item validity indicates that all items have calculated correlation coefficients (r) greater than the table value (r), indicating that all items are valid and suitable for measuring the three aspects of food security awareness. The reliability of the instrument was analyzed using Cronbach's alpha coefficient, yielding $\alpha = 0.968$, placing it in the very high category and indicating good internal consistency for measuring the cognitive, dispositional, and active aspects.



(a) (b)

English translation:	English translation:
1. I can explain how food security affects individuals, families, and communities *Strongly disagree (1) (2) (3) (4) (5) Strongly agree* *2. I can list the factors that contribute to food security* *Strongly disagree (1) (2) (3) (4) (5) Strongly agree* *3. I can list and define the four pillars of food security* *Strongly disagree (1) (2) (3) (4) (5) Strongly agree* *4. I can explain how tissue culture can help increase food availability in Indonesia as part of efforts to support food security* *Strongly disagree (1) (2) (3) (4) (5) Strongly agree*	*Look at the time-lapse image of the tissue culture process from start to finish. The correct sequence of steps, as shown in the image, is...* *A.Callus-explant-planlet-sterilization-inoculation* *B.Explant-sterilization-inoculation-callus-planlet* *C.Explant-callus-sterilization-planlet-inoculation* *D.Planlet-explant-callus-inoculation-sterilization*

Figure 3. Examples of questions to measure the effectiveness of animated video: (a) food security awareness questionnaire, (b) written test of learning outcomes

Students' food security awareness was measured before and after watching an animated video; the results of the comparison are presented in Figure 4. The increase in average scores across the three aspects was 25.83% for the cognitive aspect, 17.5% for the dispositional aspect, and 11% for the

active aspect. From the paired-samples t-test, the sig value was 0.00, which is less than 0.05. This means that H0 is rejected and H1 is accepted, indicating a significant difference in students' food security awareness scores before and after the video. Subsequently, an N-Gain test was conducted, yielding a score of 0.37, indicating a moderate increase in students' food security awareness. This is reinforced by the results of Cohen's d effect size test (d = 1.23), which indicates that the animated video has a strong, significant impact on changes in students' food security awareness.

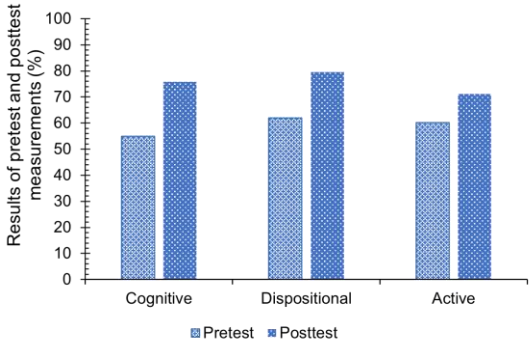


Figure 4. Comparison of students' food security awareness between pretest and posttest (percentage), as measured across three aspects: cognitive, dispositional, and active.

Table 10. Comparison of students' food security awareness before and after the lesson

Results	Average score	N-Gain score	Category
Before	43.95	0.37	Moderate
After	56.65		

Students' low food security awareness at the beginning of the learning process may be due to several factors, including the lack of integration of food security issues into science education, particularly in biotechnology curriculum (Fahmi et al., 2018). Most students believe that food security is only related to the availability of sufficient food for daily life and is not the responsibility of every individual. They have not yet realized that food security is not only related to food availability but also to access, stability, and affordable food prices. More broadly, food security is a global issue and a real problem in the students' immediate surroundings. Providing concrete examples from their local environment will help students understand the material and improve their learning outcomes (Welerubun et al., 2022). In addition to the limited integration of food security issues into science education, the scarcity of local media coverage of food-related topics may also contribute to students' low level of awareness of food security. The lack of educational content on food-related issues also results in limited information about the importance of food security, which extends beyond food availability to include its nutritional benefits (Rozaki, 2021). The importance of food security should be introduced through education starting at an early age (Widiyastomo, 2022). At the junior high school level, students' understanding should not be limited to basic cognitive comprehension but should also include practical application. In line with the 2023 policy of the Ministry of Education, Culture, Research, and Technology on Sustainable Lifestyles, awareness of food security can be grown by integrating it into simple projects. Students not only understand the concept of biotechnology but can also apply it in daily life, demonstrating how it can support food security efforts, a global concern.

The tissue culture animation video integrates the concepts of food security and tissue culture through animated visuals, audio, and on-screen text. The research results show that the animated video can enhance students' awareness of food security across cognitive, dispositional, and active dimensions. Based on Figure 4, the cognitive aspect showed the greatest increase among the three aspects. This is explained through the dual-channel processing mechanism and cognitive load theory. Animated videos provide visual representations, with audio narration offering verbal explanations that are processed simultaneously through visual and verbal channels. Presenting information gradually helps reduce cognitive load, making it easier for students to integrate the concept of food security, a new concept into their existing knowledge structure and strengthen their memory. This mechanism aligns with the multimedia learning theory proposed by Mayer (2014), which states that learning occurs more effectively when information is presented through a well combination of images and words. Therefore, the characteristics of animated videos that systematically integrate visuals, audio, and text, can contribute to enhancing students' cognitive development. The development

of comprehensive knowledge and understanding of food security issues is a crucial foundation for building students' awareness, as knowledge is the initial stage underlying the formation of attitudes and tendencies to act (Stevens et al., 2020).

Table 11. Aspects and indicators of food security awareness (Sánchez & Lafuente, 2010)

Aspect	Indicator
Cognitive (Knowledge and Understanding)	• Knowledge of the importance of food security • Understanding of issues related to food security
Dispositional (Attitude)	• Attitudes or behaviors supporting food security • Concern for food security issues
Active (Action and Participation)	• Participation in food security efforts

Animated media that present food security issues encourage students to care about them. Problems such as hunger, malnutrition, and limited access to food are real issues that can arise in life. Students are required to find solutions to existing problems, thereby fostering two important attitudes: caring and responsibility. Improved cognitive aspects will affect dispositional aspects. Students who understand food security issues and solutions tend to have a greater sense of care and responsibility. In line with research conducted by Handayani & Sopandi (2016), increased cognitive abilities will influence students' caring attitudes.

Enhancements in active engagement indicate that animated videos can encourage students to actively participate in food security initiatives. This medium not only explains concepts but also provides examples of concrete actions students can take, at the end of the video, there is a call to action encouraging direct participation in food security efforts. After the treatment, students stated that they would contribute to food security efforts. According to one of the active aspect questionnaire statements, students are willing to start food security efforts by inviting others to contribute to them and by sharing content related to food security issues. The results indicate that animated videos can encourage positive attitudes and a willingness to act, channeling knowledge and awareness into concrete actions. However, the improvement in cognitive aspects was the lowest among the three aspects. Behavioral change develops more slowly than knowledge and attitudes. According to Currey et al., (2018), the formation or change of behavior requires a longer period of time, direct experience among students, and continuous reinforcement. Therefore, the development of cognitive and dispositional aspects serves as a crucial foundation for the emergence of active aspects in the future (Sahadeo et al., 2025).

Research has shown that animated media on tissue culture can increase students' food security awareness. The N-Gain test results indicate a moderate increase in food security awareness scores, a finding supported by the effect size test, which shows that animated videos have a significant impact on students' food security awareness. The combination of visuals, animation, and a narrative makes the material more engaging and less boring, making the information easier to understand and remember. Through a contextual approach, animated videos that combine tissue culture with food security issues can elevate students' awareness, from concern to active steps to support food security. Students not only understand the importance of food security but also recognize their responsibility for food sustainability in Indonesia. They also expressed a willingness to actively encourage others to contribute to food security efforts, one of which begins by sharing content related to food security issues. The results of this study are consistent with research by Alissa (2022) and Sahadeo et al. (2025), which found that sustainability education can raise awareness by enhancing students' knowledge, attitudes, and propensity to take concrete actions in support of sustainability. This study expands on those findings by demonstrating that the development of animated videos integrating tissue culture as an alternative solution to support food security is also effective in building awareness of food security. In contrast, research conducted by Cahyani et al. (2025) indicates that environmental knowledge does not directly influence student behavior. In the present study, the animated video successfully encouraged students' willingness to contribute actively to food security efforts. The contextual approach in the animated video, which explicitly integrates tissue culture and food security

issues, coupled with direct calls to action and concrete examples, can reduce the limitations in the relationship between knowledge and behavior identified in Cahyani et al.'s study. This aligns with Orr's (1992) Awareness-Raising theory, which posits that visual media, such as animation, can transform attitudes from passive to proactive.

The moderate level of food security awareness among students may be attributed to the integration of food security concepts, which are still new to them, as well as a lack of time for research and insufficient preparation for student participation in the learning process. Further enhancing food security awareness requires sustained efforts over a longer period and practical application. This research can serve as a preliminary overview for the broader application of animated videos on tissue culture and more structured learning. Additionally, this media holds significant implications for use in science education based on Socio-Scientific Issues (SSI) by enhancing awareness. Food security, a global issue, encompasses multiple dimensions that integrate insights from biology, social economics, and environmental ethics. This medium can facilitate SSI discussions by visualizing tissue culture stages and related food security issues, which is expected to encourage active efforts to support food sustainability. Development of similar media can also be applied to other science subjects requiring conceptual visualization, particularly those involving abstract and step-by-step concepts, by adding interactive elements such as quizzes that encourage student engagement in learning.

The effectiveness of the animated video was also measured by students' learning outcomes using a written test comprising 15 multiple-choice questions. The instrument used was found to be valid, as the test results showed that all items had calculated correlations (r) greater than the r table, indicating that all items were valid and reliable. The instrument was also found to be reliable based on the results of the Cronbach's alpha test, with a value of $\alpha = 0.683$ in the moderate category, indicating that the instrument has adequate reliability and can be used in research, particularly in the early stages of development research. The results of the student learning assessment are presented in Figure 5, which shows an improvement in student learning outcomes following the intervention. The data obtained were tested against classical assumptions to determine their distribution, and the analysis continued with a non-parametric test, namely the Wilcoxon test. The Wilcoxon test yielded a p-value of 0.00, which is smaller than 0.05, indicating that H0 is rejected and H1 is accepted. This indicates a significant difference between the pre-test and post-test results for student learning outcomes. The magnitude of the improvement in learning outcomes was measured using the N-Gain test, which indicated a high level of improvement in students' cognitive learning outcomes, with a score of 0.77. This was reinforced by the results of the Cohen's d effect size test, which showed a score of 0.88 in the large category. The test results indicate that animated videos have a strong influence on students' learning outcomes.

Animated media, in the form of tissue culture videos, have been shown to improve student learning outcomes in the high category. In accordance with the Cognitive Theory of Multimedia Learning proposed by Mayer (2009), learning is more effective when information is presented by combining visual and verbal elements in ways that align with how the human cognitive system works. The integration of motion pictures, text, and audio within a structured video helps students construct knowledge more systematically and gradually as they reconstruct their understanding. Newly learned knowledge is processed through two distinct channels, which can facilitate the integration of new knowledge with what students already possess. This aligns with the findings of Ardianti et al. (2025), who found that animated media helps students understand material by visualizing abstract concepts, thereby enhancing learning outcomes. The use of animated media in learning activities can stimulate student learning, increase learning effectiveness, and help in achieving the goals of understanding and remembering the material.

Science learning is abstract, involving broad concepts that require detailed understanding to develop concrete understanding (Cahyaningrum & Abidin, 2022). Tissue culture is a complex scientific subject that involves several stages. It requires media that can present the material with clear and gradual visualization. Animated media is a dynamic visual representation that can provide a clearer picture of

stages, processes, and changes, thereby supporting active learning. Animated videos can realistically represent real environments. In addition, animated videos can illustrate processes effectively and allow for repeated viewing (Utaminingsih & Kassymova, 2024). The use of animated media can optimize student learning outcomes because students tend to be more interested in learning through animation, leading to a better understanding of the material (Amali et al., 2020). The effectiveness of animated media in the learning process is demonstrated by research on animated tissue culture media that not only present the stages of tissue culture but also address food security issues, with tissue culture as one of the solutions. The animated media also presents a comparison of traditional agricultural practices and the use of technology. Presenting concepts with clear, step-by-step visualizations in the form of images, audio, and text can improve student learning outcomes, as evidenced by improved post-test results.

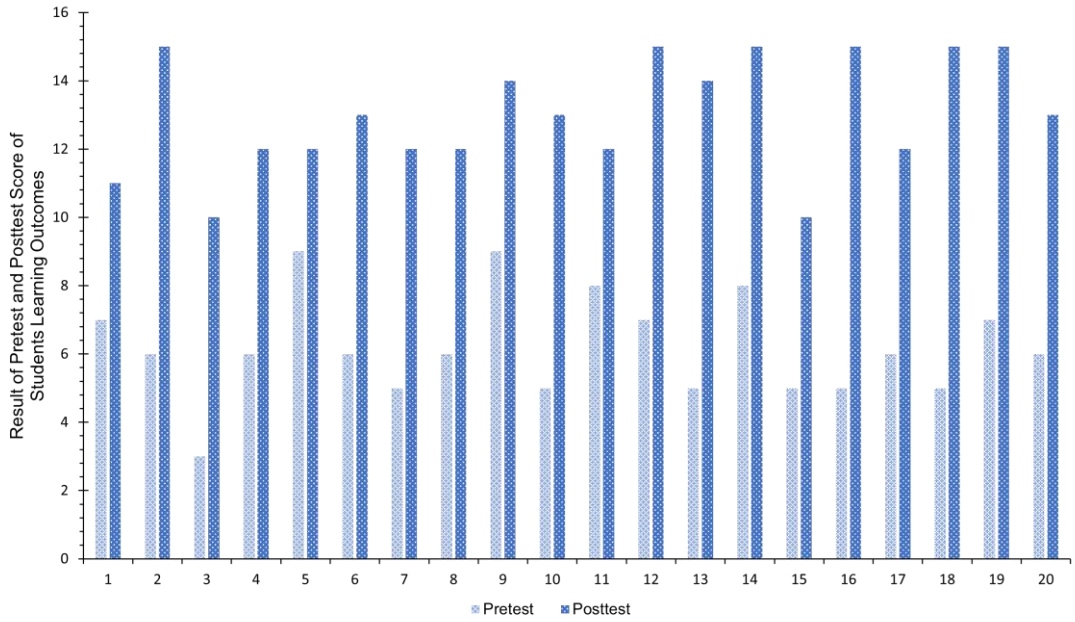


Figure 5. Comparison of students' learning outcomes based on pretest and posttest scores for 20 students, assessed using a 15-item instrument.

Table 12. Comparison of Student Learning Outcomes

Results	Average score	N-Gain score	Category
Pretest	41.33	0.77	High
Posttest	86.66		

CONCLUSION

This study indicates that animated videos integrating the concepts of tissue culture and food security have proven to be valid, practical, and effective for use in junior high school science education. Animated videos on tissue culture have been shown to enhance students' awareness of food security (cognitive, dispositional, and active aspects) and their cognitive learning outcomes, as assessed in a small-scale trial as an initial overview for broader educational applications. The findings reinforce Mayer's theory on the ease of knowledge reconstruction through two distinct channels (visual and auditory) and provide empirical evidence that integrating animated media with relevant global issues can foster students' awareness. The results of this study contribute to enriching the junior high school science curriculum by integrating concepts of food security and biotechnology through engaging animated videos. Animated videos on tissue culture can serve as a reference for innovative instructional media, taking into account content suitability, animation complexity, and student characteristics.

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AUTHOR'S CONTRIBUTION

Asma Amaniatul 'Ulya: Data curation, media design, writing, original draft.

Fidia Fibriana: Funding acquisition, software license, writing and editing, review, and supervision.

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