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Development of E-Comics on Biotechnology Materials Equipped with Factual Videos for Scientific Literacy Skills

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Abstrak

Bioteknologi mungkin membingungkan. Komik membuat pembelajaran lebih menarik, menyenangkan, dan mudah dipahami dengan bercerita. Inovasi menciptakan e-komik menggunakan rekaman faktual. Penelitian ini mengkaji kelayakan, keterbacaan, dan reaksi siswa terhadap media e-komik bioteknologi dengan video faktual. Penelitian ini mengikuti metodologi pengembangan ADDIE dari analisis hingga desain, pengembangan, implementasi, dan penilaian. Penelitian ini melibatkan siswa kelas XII SMA Sultan Daulat 1 yang dipilih secara acak. Penelitian ini menemukan bahwa 1) media e-komik bioteknologi yang disertai video faktual memiliki skor validasi materi sebesar 84% dan validasi media sebesar 93% dengan kategori sangat valid. 2) Media komik memperoleh skor keterbacaan sebesar 81,4% dengan kategori sangat baik. 3) Jawaban media komedi siswa memperoleh skor 82% sangat baik. Temuan ini menunjukkan bahwa media e-komik bioteknologi dengan video faktual valid dan dapat digunakan untuk pembelajaran.

Kata Kunci; *Bioteknologi; Komik elektronik; Video faktual; Literasi sains; ADDIE*

Abstract

Biotechnology can be confusing. Comics make learning more engaging, fun, and understandable by telling stories. Innovation creates e-comics using factual recordings. This study examines the feasibility, readability, and student reactions to biotechnology e-comic media with factual videos. This study follows the ADDIE development methodology from analysis to design, development, implementation, and assessment. This study involved randomly selected grade XII students of Sultan Daulat 1 High School. This study found that 1) biotechnology e-comic media accompanied by factual videos had a material validation score of 84% and media validation of 93% with a very valid category. 2) Comic media obtained a readability score of 81.4% with a very good category. 3) Students' answers to comedy media obtained a very good score of 82%. These findings indicate that biotechnology e-comic media with factual videos is valid and can be used for learning.

***Keywords**:* Biotechnology; E-comics; Factual video; Science literacy; ADDIE

1. INTRODUCTION

Scientific literacy is using scientific knowledge to solve problems, learn new things, explain phenomena, and draw conclusions from data. Latin is used in biology (S1), an undergraduate science course that studies living things (Nasution et al., 2023; Juriah and Zulfiani, 2019). High school biology covers life and the environment (Harahap et al., 2020). Biology involves ideas, methods, outcomes, and applications. The biology learning process must include these four components so students can experience it holistically, grasp natural phenomena through problem-solving and scientific techniques, and mimic scientists' discoveries. Biology needs cognitive, emotional, and psychomotor skills (Situmorang et al., 2019). According to Ismiati (2020), biology courses equip students with scientific and technological abilities to make informed decisions based on scientific principles and moral values. Agriculture, livestock, fisheries, energy, environmental health, and science employ biotechnology. Biotechnology is a vital capability in open-ended skills development and should inform real-world students who need 21st-century abilities (Fatmah, 2021). Research suggests Indonesian pupils' scientific literacy is low. Indonesian students placed 71st out of 79 countries in 2018 and 67th out of 81 in 2022, with average scores of 396 and 383, respectively. Although Indonesia ranks higher, these achievements show that its average scientific literacy skills in 2022 have fallen from 2018. This also shows that Indonesian students can only learn basic facts but cannot apply them to scientific difficulties, especially in daily life (Sutiani et al., 2020). Indonesia's climate lacks assessment items, especially for technology and information development (Muskania and Wilujeng,2017).

XII-grade pupils at Sultan Daulat 1 State Senior High School in Aceh Province lack scientific literacy. From early learning, many 12-grade students were unable to answer biotechnology science literacy questions at process and context markers of scientific applications and cognitive levels C4, C5, and C6. Interviews with 10 12-grade pupils showed that biotechnology requires current, hard-to-access technologies. Modern and ancient biotechnology are included in biotechnology content. Biology professors at Sultan Daulat 1 State Senior High School, Sultan Daulat Regency, Aceh Province, also reported that pupils' biotechnology learning outcomes remain low year after year, requiring remedial sessions. Low student achievement in biotechnology is caused by many factors. One is that instructors' dull learning method has not been fully used to teach biotechnology essentials.

The incorrect assumption that biology is difficult and just takes memorization significantly lowers student biology learning achievement because most students are less interested about learning it. Situmorang et al. (2019) found that most biology students take notes and listen to the instructor because they see lessons as memorizing. According to Hasairin and Apriyanti (2018), the biology learning process has several issues, including (1) ineffective learning models, (2) students are less motivated to learn because they don't understand the learning mechanisms, and (3) low student learning outcomes because only a few questions can be answered

PowerPoint presentations are used in biology classrooms. Students also want more engaging media to learn, according to interviews. A needs analysis from a preliminary study at SMA Negeri 1 Sultan Daulat, Sultan Daulat Regency, Aceh Province, found that ineffective biology teacher learning

models, a lack of teaching materials, and inadequate media use caused low student achievement in biology, including biotechnology. Learning involves teachers, students, learning objectives, resources, strategies, tools/media, the environment, and evaluation. Whatever promotes reciprocal teaching and learning to attain goals is teaching material. Their proper use improves learning. Good instruction gives students knowledge, skills, and experience. (2022, Zaimah et al.) Learning activities let students think rationally, critically, and creatively, debate, communicate, and collaborate to address global problems, and make data-driven decisions. Scientific literacy consolidates science, scientific knowledge, and abilities like research, critical thinking, problem-solving, and drawing conclusions to help pupils socialize, develop, and participate in community life. Learning resources must be innovative and developed. Classroom learning depends on teachers. Teachers must help students create effective learning materials. Education materials include textbooks and other tools (Harahap et al., 2019). Open learning resources can affect learning results. Open resources give instructors expertise, tools, and texts to organize and review learning. Learning materials improve student and collaborative learning. Engaging, practical, effective, and interactive teaching materials can also improve classroom learning (Sahara et al., 2018).

Students and educators can learn about biotechnology using open e-comics with unique aspects like factual documentaries. E-comics, with appealing graphics and hilarious stories, are open learning materials. Comics improve literacy and imagination in students. Interactive e-comics have photographs, panels, dialogue bubbles, character figures, and amusing body movements (Suprianingsih et al., 2022). Synchronizing students' right and left brains with e-comics improves learning. Story theme, place, time period, atmosphere, point of view, storyline, characters, and message are also part of comics. These elements can be illustrated to clarify ideas. Graphics communicate through words, making comics educational (Umar et al., 2023). Learning is more fun with e-comics and factual documentaries. Audiovisual media includes sound and images. Video media teaches consumers visually and audibly. Learning films are more tactile than print media (Herayanti et al., 2019). Videos combine visual, aural, and movement to enhance learning. This media can engage students, clarify instructor explanations, and concretize abstract subjects. Videos standardise classroom content (Wulansari et al., 2022). True videos are based on genuine events. Realistically presented educational videos improve student learning (Farsa et al., 2022).

2. RESEARCH METHODS

This development research was validated and evaluated by expert validators (professors) from the Postgraduate Program at Medan State University, and product implementation was conducted at SMAN 1 Sultan Daulat, Jambi, Sultan Daulat District, Subulussalam City, Aceh Province, Zip Code 24782. The research lasted two months, November–December 2024.

This research and development involved two expert validators (biology teachers), two high school biology teachers, and two 12th grade students at SMAN 1 Sultan Daulat: an experimental class (30 students) and a control class (30 students). The subjects of this study were electronic comics and factual films about biotechnology for 12th graders.

Research is R&D that produces a product, not tests a hypothesis. Instructional research and development creates and validates instructional materials (Setyosari, 2016) and evaluates product success (Sugiyono, 2020). Research and development findings are provided as biotechnology teaching resources for 12th grade secondary school students in the form of electronic comics with factual films.

3. RESULTS AND DISCUSSION

Results of the E-Comic Effectiveness Test

The effectiveness of e-comics on biotechnology material supplemented with factual videos on students' scientific literacy skills was analyzed based on the results of the scientific literacy assessment (pre-test and post-test) between experimental class students (30 students in grade XII IPA-2) who were taught using e-comics supplemented with factual videos, and control class students (30 students in grade XII IPA-3) who were taught directly without e-comics. The test instruments used for the pre-test and post-test were the same, except for randomization of the question numbers and answer choices. This was done to control for the instrument effect. This means that the influence or effectiveness of e-comics on biotechnology material supplemented with factual videos on students' scientific literacy skills is not due to differences in the test instruments used during the pre-test and post-test.

Data regarding the initial scientific literacy skills (pre-test) of students in the experimental and control classes are summarized in Table 1.

Table 1. Summary of students' initial scientific literacy data (pre-test)

Class	Science Literacy Indicators	**N**	**Mean**	**Std. Deviasi**
Experiment Class	Science Content	30	48.93	24.551
	Science Process	30	40.60	20.822
	Science Application Context	30	31.83	12.996
	Pretest Total	30	37.17	6.390
Experiment	Science Content	30	46.63	25.854
	Science Process	30	38.37	21.034
	Science Application Context	30	32.70	7.653
	Pretest Total	30	36.67	5.467

Table 1 Pre-test science literacy skills did not differ between experimental and control class students. Average total score for experimental class was 37.17 ± 6,390, whereas control class had 36.67 ± 5,467. The difference in average total score was 0.50 (37.17 - 36.67). The experimental class had a pre-test score of 48.93 ± 24.551, while the control class had an average score of 46.63 ± 25.854, resulting in a 2.30 difference in scientific content indicator value. Students in the experimental class scored 40.60 ± 20.822 on the scientific process indicator, whereas those in the control class scored 38.37 ± 21.034, a 2.23 difference in scientific content scores. The experimental class had a pre-test score of 31.83 ± 12.996 on the scientific application context indicator, while the control class had 32.70 ± 7.653 on the scientific content indicator, resulting in a difference of 0.87 (32.70 - 31.83 = 0.87). The pre-test scientific literacy scores of both classes before learning were still very low or below the KKM score for biology topics at SMA Negeri 1 Sultan Daulat Aceh, which was 75.

The final data on the scientific literacy skills (post-test) of students in the experimental and control classes are briefly summarized in Table 2.

Table 2. Summary of final data on students' scientific literacy skills (post-test)

Kelas	Scientific Literacy Indicators	N	Mean	Std. Deviasi
Percobaan	Scientific content	30	95.60	11.410
	Scientific process	30	78.87	15.627
	Scientific application context	30	75.33	14.907
	Number of publications	30	79.33	10.886
Kontrol	Scientific content	30	92.30	14.196
	Scientific process	30	71.13	19.440
	Scientific application context	30	65.00	15.024
	Number of publications	30	70.83	11.071

Table 2. compares the post-test scores of experimental and control class students in scientific literacy after different learning actions. The experimental class had an average total post-test score of 79.33 ± 10.886, while the control class had an average score of 70.83 ± 11.071, resulting in an average score difference of 8.50. In the scientific content indicator, experimental students had an average post-test score of 95.60 ± 11.410, while control class students had an average score of 92.30 ± 14.196, resulting in a score difference of 3.30. Students in the experimental class obtained a score of 78.87 ± 15.627 on the scientific process indicator, while students in the control class obtained a score of 71.13 ± 19.440, resulting in a score difference of 7.74 for the scientific content indicator. The average post-test score of experimental class students on the science application context indicator was 75.33 ± 14.907, while for control class students, the average post-test score was 65.00 ± 15.024 with a difference in the post-test scores of the two classes on the scientific content indicator of 10.33 (75.33 - 65.00 = 10.33). These results indicate that there is a significant difference in the final science literacy ability (initial test) between the two classes after the learning was carried out, both seen from the total score of the final test and each indicator.

Using SPSS 26.0, an independent sample t-test can be used to assess the impact of biotechnology e-comics with factual videos on students' scientific literacy. Data normality and homogeneity tests using the Kolmogorov-Smirnov and Levene tests were conducted before hypothesis testing. The pre-test and post-test data normality tests for both courses are shown in Table 3

Table 3. Results of data normality test

Class	Data	*Kolmogorov Smirnov Test*	Sig.	Description
Experiment	Pretes	0,938	0,342	Normal
	Postes	1,047	0,223	Normal
Control	Pretes	1,072	0,201	Normal
	Postes	0,986	0,285	Normal

Table 3. shows the results of the data normality test using the Kolmogorov Smirnov test method, both for the pre-test and post-test data for each sample class, the probability value or sig. > 0.05 is obtained, which means that all the data tested are stated to have a normal distribution or have met the normality criteria.

DISCUSSION

To enhance biotechnology education, e-comics are created utilizing AI Image Generator, Microsoft Word, and HTML5 flipbook apps, along with factual films on YouTube. E-comics for biotechnological materials and expandable factual movies are 21st-century learning innovations. An interesting style helps students learn and understand. Reviewing information wherever and anytime helps students learn independently. Links for students make it easy to access. Biotechnology e-comics incorporate factual videos. These comics also meet National Standards Agency (BSNP) criteria for teaching material content, presentation, language, and graphic medium. For content, language, presentation, and graphics, BSNP evaluates excellent educational materials under Government Regulation No. 32 of 2013 (Ningtyas and Rahmawati, 2023). A team of material and media expert validators designed, verified, and reviewed a biotechnology e-comic with factual videos for classroom usage at the biotechnology learning level.

The material expert validation team verified the biotechnology e-comic with factual videos meets BSNP content, presentation, and language requirements. Homogeneity index with core competencies (KD), application, and curiosity-building determines eligibility. Presentation eligibility depends on tactics, learning, coherence, and mental process sequence. Its eligibility depends on language openness, communicativeness, dialogicity, interactivity, and student progress. The material expert validator team found the biotechnology e-comic featuring factual videos eligible for classroom use. See if e-comics biotechnology is viable. The media validation expert panel verified factual videos fit BSNP numerical and qualitative requirements, including graphical eligibility. The media validation expert team considered the e-comic's cover and content design indicators useful. E-comic graphics and media are visual. Biotechnology e-comic material is suitable, according to assessment results. Equipped with classroom-ready factual films. Many research have explored e-comics as learning medium, open resources, and modules. Telaumbanua and Zega (2023), Febriani et al. (2020), Naziroh (2021), Filjinan, Kasih, Oktaviana, and Ramadhani (2023), Ayu, and Nedy (2024) found that e-comics are great for learning. E-comics can be used for education, according to Puyanti, Dakunya, and Sobari.

Biology instructor and student questionnaire replies corroborate biotechnology e-comics with factual films' usefulness. A study of three biology teachers and 30 second-graders at Sultan Daulat 1 State Senior High School (SMA Negeri 1 Sultan Daulat) found that e-comics with factual videos improved attention, content, and language indicators. These results show that biotechnology e-comics with factual films are practical and easy for Grade 2 pupils to use as learning aids for high school biotechnology. Several studies have examined the practicality of using e-comics (digital comics) in learning activities, including Febriani et al. (2020), Nazhiroh et al. (2021), Filjinan et al. (2022), Wulansari et al. (2022), Telaumbanua and Zega (2023), Adawiyah et al. (2024), Ayu et al., Dakunya, and Nedy. Farsa et al. (2022) found that teachers found comic-based e-modules containing factual films useful for learning. Electronic comics can improve children's scientific literacy. Electronic comics can help children understand science and enjoy reading. Electronic comics are entertaining and can help students learn by visualizing the content (Rahma and Kusumawati, 2024). Comics are used to spark students' interest in reading, which should lead to a love of reading (Ditriguna et al., 2023). Students who enjoy reading comics will read more and for longer periods, which encourages good reading habits and academic success (Nurhakim et al., 2024).

Factual videos, authentic videos from real life, can help improve students' scientific literacy. Factual films enhance student learning by presenting educational content realistically (Farsa et al., 2022). Videos can also help students better understand scientific concepts (Nafingah et al., 2024). Factual films can teach science to children in an engaging way. Based on the statistical analysis of post-test data, students in the experimental class who were given biotechnology learning using e-comics equipped with factual videos

(79.33) had higher science literacy skills than students in the control class who received direct learning without e-comics (70.83), with a difference of 8.50 in the average post-test score. The results of the analysis also showed that students in the experimental class had higher science literacy skills in the content, process, and context indicators of science applications compared to students in the control class. Thus, e-comics on biotechnology material accompanied by factual videos can improve the science literacy skills of class XII students of SMA Negeri 1 Sultan Daulat, Sultan Daulat Regency, Aceh.

4. CONCLUSION

Material specialists (content, presentation, and language) and media experts (e-comic cover design and content design) validated biotechnology e-comic teaching materials using factual videos. Biotechnology e-comics with factual films were produced and implemented in 2024/2025 for grade XII students at SMA Negeri 1 Sultan Daulat, Sultan Daulat Regency. Biology teachers' readiness, the way they implemented the lessons, and the results of their assessments provided the basis. The e-comic containing factual videos greatly enhanced science literacy abilities for grade XII students at SMA Negeri 1 Sultan Daulat, Aceh, in 2024/2025, as shown by post-test scores and statistical test results ($p < 0.004$).

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