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Development of Digital Infographic Based on Housefly Exoskeleton Bacterial Identification

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Abstract: Digital infographics can be an alternative visual learning media that can be used both inside and outside the classroom. Content related to bacteria in relevant learning media is very important, as bacteria can be found almost everywhere, including on the exoskeletons of houseflies. Therefore, the aim of this study is to develop a digital infographic based on the identification of bacteria on the exoskeletons of houseflies using the ADDIE development model. Product validation was carried out by 3 experts, and implementation was conducted with 32 tenth-grade students at SMAN 20 in Gowa Regency. This digital Eubacteria infographic is a visual representation of research conducted in the FMIPA UNM laboratory. It illustrates six different types of bacteria identified from the exoskeleton of houseflies, complete with microscopic images and a brief description of each bacterium's characteristics. The infographic is packaged as an application accessible via Android smartphones. The results of the study show that the digital infographic was rated as very valid with an average score of 94%, very practical with an average score of 96%, and highly effective with an N-gain value of 0.8. This study indicates that the use of contextual learning media can improve students' learning outcomes.

Keywords: Bacteria; Digital infographic; Housefly; Learning media

Introduction

The teaching and learning process are a change in a person's behavior that occurs at the level of knowledge, skills, or attitudes. To enhance knowledge and skills, the teaching and learning process requires creative teachers (Lativa et al., 2021). The use of learning resources that reflect real-life situations greatly supports optimal interaction between students and learning materials. Efforts to foster an understanding of students' learning development can be done by developing learning media such as handouts, booklets, leaflets, pocketbooks, popular science books, encyclopedias, Android-based applications, and others (Asih et al., 2023).

Wulandari et al. (2023) state that one way to increase students' interest in learning is by using tools or media that not only serve as attractive learning resources but also overcome limitations in space, time, effort, and sensory perception. The use of Android-based learning media is one application of 21st-century learning styles (Firdaus et al., 2021). The learning media developed is embedded in an Android application, allowing students to access it without time limitations.

Firdaus et al. (2021) in their research results showed that the Android-based infographic media is portable and easy to use due to its Android platform, it can be used offline, minimizing connectivity issues, it is affordable and free, requiring only installation on a device to operate, the material is easy to understand and attractive as it is presented in infographic and systematic formats. Infographics, derived from the word 'infographics' in English, which is a combination of 'Information + Graphics,' are a form of data visualization that conveys complex information to readers in a way that is easier and faster to understand (Saptodewo, 2014).

Infographics can be an alternative learning media that can be used both inside and outside the classroom.

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The unique form and appearance of infographics can attract students' interest in learning. Infographics have also been widely used as learning media in Biology subjects, one example being the research by Hakli et al. (2022) which produced animated infographic media aimed at teaching the ecosystem topic in Biology. The scope of study in Biology is vast and contains many interesting facts that can be integrated into the general framework of biological knowledge. Each kingdom plays a crucial role in various fields such as health, industry, and ecology (Wulandari et al., 2017).

Based on interviews with a Biology teacher for grade 10th at SMAN 20 in Gowa Regency, one of the difficult topics for students in the Monera kingdom, particularly in the 10th-grade Biology curriculum, is the discussion about Eubacteria. Students also rely only on textbooks as their daily learning resource. As a result, students find it increasingly difficult to understand the topic of Eubacteria, as it is complex, uses many foreign terms, and requires illustrations to clarify the theory. This often leads to students quickly forgetting the material.

Noer (2021) states that bacteria in various quantities, types, and characteristics can be found almost everywhere. A study conducted by Carneiro et al. (2014) in Brazil identified several bacterial species found in flies, such as: *Aquaspirillum polymorphum*, *Burkholderia ambifaria*, *Burkholderia anthina*, *Burkholderia cepacia*, *Burkholderia cenocepacia*, *Burkholderia pyrrocinia*, *Burkholderia stabilis*, *Paenibacillus macerans*, *Virgibacillus pantothenticus,* and *Bacillus subtilis*. Another study by Putri (2018) at the Jakabaring Market in Palembang found that houseflies (*Musca domestica* Linn) were identified as vectors of *Salmonella sp.* and *Proteus sp.* The exoskeleton of houseflies was identified to carry *Escherichia coli* and *Salmonella sp.* (Ibrahim et al., 2018).

Flies are cosmopolitan pests (vectors) closely associated with human activities. Flies can transmit pathogens to humans due to their habit of visiting unsanitary places and human food. Pathogens can be transmitted through parts of their bodies such as their legs, hairs, and other contaminated body parts. The spread (distribution) of pathogens by flies can be extensive due to their flying range (Pranajaya et al., 2020). Sari et al. (2023) mention that there are at least 65 diseases believed to be transmitted by flies, including typhoid fever, dysentery, and cholera, which can infect humans. Umarudin et al. (2023) also state that diarrhea can be caused by several bacteria found on the bodies of flies, such as *Escherichia coli*, *Salmonella sp.*, and *Shigella sp.*. Therefore, the identification of bacteria in houseflies can be an important source of material that can be used as content in contextual learning media at schools. With such learning media, it is hoped that students will be more cautious about maintaining environmental cleanliness and prevent diseases caused by bacterial contamination on fly bodies.

Based on the needs assessment and literature review conducted by researcher, the solution carried out by the researcher is to develop a digital infographic as a contextual learning resources based on the results of bacterial identification on housefly's exoskeleton. The novelty of this research lies in the development of Android-based digital infographics that combine the identification of bacteria on the exoskeleton of houseflies (*Musca domestica*) as a contextual learning tool. This approach is innovative because it integrates real-world content, such as bacteria commonly found on flies, into Biology education, making the material more relevant to students' daily lives. The study also pioneers the use of infographics as an interactive, visual learning medium that enhances student engagement and facilitates the understanding of complex biological concepts. Furthermore, the research includes a comprehensive evaluation of the validity, practicality, and effectiveness of the developed learning media, providing empirical evidence of its positive impact on students' learning outcomes. This combination of contextual content, modern technology, and validated learning media offers a novel approach to improving student comprehension in Biology education.

Method

The digital infographic development was carried out using the ADDIE model. The ADDIE design creation model consists of several steps, namely Analysis, Design, Development, Implementation, and Evaluation. The analysis phase is the stage of gathering field information, which serves as the basis for the need to develop a media in the form of a digital infographic based on research on the identification of bacteria on the exoskeleton of houseflies in the topic of bacteria. This includes curriculum analysis, learning needs analysis, and content analysis. In this stage, the researchers obtained primary data through interview with Biology teachers at SMAN 20 in Gowa Regency.

At the design stage, the researchers start to develop designs by creating a flowchart and storyboard for digital infographic, draft validation sheet instruments, draft product practicality and the effectiveness instrument is in the form of multiplechoice questions, consisting of a total of 15 items. Canva is a software used for designing the visual layout of infographics, while Sketchware is a software used for producing digital infographics in the form of applications that can be installed on Android smartphones. Canva was chosen because this software is easy to use and offers a wide variety of attractive elements. Sketchware was selected for this study because it is user-friendly, free of charge,

and can be installed and operated directly on Android smartphones.

In the development stage, the developed media will be validated three expert lecturers. Likert scale of 4 (strongly agree), 3 (agree), 2 (disagree), 1 (strongly disagree) is used to assess the validity and practically of the digital infographic. After the items are scored by the expert, the percentage is then sought using the validity and practically formula based on Sugiyono (2015) presented in Formula 1.

$$\text{Average score (\%)} = \frac{\Sigma \text{ Total score}}{\Sigma \text{ Maximum score}} \times 100\% \quad (1)$$

Based on the validity value that has been obtained, validity categories are determined as stipulated in Table 1. Revisions are made, if there are suggestions for improvement from the experts. After that, the digital infographic is ready for implementation to the experimental class of 10th grade students at SMAN 20 Gowa regency, the research subjects were 32 students.

The implementation stage was conducted over three meetings. A pre-test was administered during the first meeting, followed by an introduction to the digital infographic application on Eubacteria, which had been installed on each student's smartphone. During this session, the discussion also covered the unique characteristics and structure of bacteria. The learning implementation observation sheet was completed by the Biology teacher during the first and second meetings. The second meeting focused on the classification and roles of bacteria found on the exoskeleton of houseflies. To support students' understanding, worksheets were provided during the first and second meetings, encouraging students to independently search for information and engage in group discussions to answer the given questions. In the third meeting, a post-test was conducted by summarizing all the material covered in the previous two sessions. Additionally, student and teacher response questionnaires were distributed to evaluate the use of the Eubacteria digital infographic in the teaching and learning process.

After obtaining the data, the data processing was analyzed using the practically formula presented in Formula 1. The categories on Table 1 is modified from Fitrahtunnisa et al. (2022). The product is considered valid and practical if the average score ≥ 71%.

Table 1. Validity and practically categories

Average score (%)	Validity categories	Practically categories
86–100	Highly valid	Highly practical
71–85	Valid	Practical
51–70	Slightly valid	Slightly practical
0–50	Not valid	Not practical

The effectiveness of digital infographic will be known by observing the improvement in students learning outcomes before and after using digital infographics is conducted by applying the N-gain formula. The N-gain score (g) obtained represents the difference between the average pretest and posttest scores. The product is considered effective if the N-gain score (g) ≥ 0.7. The effectiveness of digital infographic is calculated using Formula 2 and the N-gain categories presented in table 2 based from Ayuardini (2023).

$$\text{N} - \text{gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}} \quad (2)$$

Table 2. N-gain categories

Score	Categories
(N-gain) ≥ 0.7	Highly effective
0.7 < (N-gain) ≥ 0.3	Medium effective
(N-gain) < 0.3	Slightly effective

At this evaluation stage, researchers make the last revision of teaching materials developed based on input obtained from field notes at the previous implementation stage. This is done so that the teaching materials developed are really appropriate and can be used by wider schools. This last stage is the conclusion of all the stages that are useful to see if all the previous stages have been successful or there are still some that need to be improved again (Martatiyana et al., 2023).

Result and Discussion

Table 3. Bacterial identification of housefly's exoskeleton

Houseflies Sample	Selective media code	Name of Bacteria
Boarding houses	EMBA 1	*Escherichia coli*
Postgraduate campus	EMBA 2	*Escherichia coli*
	MSA 2A	*Staphylococcus epidermidis*
	MSA 2B	*Staphylococcus aureus*
Biology department campus	EMBA 3	*Enterobacter sp.*
	MSA 3	*Staphylococcus aureus*
	TCBSA 3A	*Vibrio parahaemolyticus*
	TCBSA 3B	*Vibrio cholerae*

Based on the research conducted, the results in bacterial identification of housefly' exoskeleton shows that there are 6 species of bacteria. The six bacteria were found on nine houseflies originating from boarding houses (3 flies), the UNM postgraduate campus (3 flies), and the FMIPA UNM Parangtambung campus (3 flies). The highest number of bacterial types was found on houseflies from the FMIPA UNM campus, totaling four types of bacteria. Meanwhile, one type of bacteria was

found on houseflies from the boarding houses, and three types of bacteria were found on houseflies from the UNM postgraduate campus. The results are presented in Table 3.

At analysis stage the researcher obtained the results, based on need assessment the students need a contextual alternative learning media that can be used both inside and outside the classroom about Eubacteria concept. The infographic draft was designed to align with the learning achievements and learning objectives of the independent curriculum implemented at SMAN 20, Gowa Regency. At the develop stage, the developed infographic draft will be validated three expert lecturers are presented in Figure 1.

Figure 1. Sample part of the digital infographic that has been developed

Table 4. Expert validation results

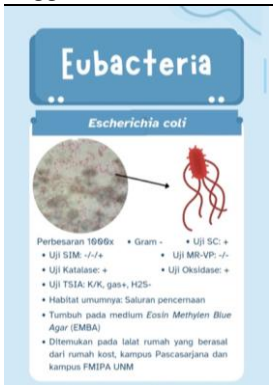
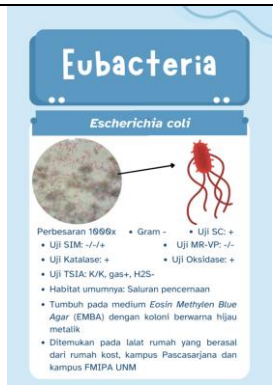
Average score (%)	Validity categories
94	Highly valid

The results of validation by expert lecturers are presented in Table 4. Product validation by 3 expert lecturers consist of several indicators, such as the suitability of the content with the learning outcomes, systematic presentation of the content, depth of the material is appropriate to the students cognitive level, the alignment of images with the presented material, the alignment of practice questions with indicators, appropriate layout, color composition, background, font size and type, image quality, ease of using the media, compliance with the rules of the Indonesian language and appropriateness of the language to the students' cognitive level.

Based on the results in Table 4, developed digital infographic shows the category highly valid with 94%

score. There are some suggestions from expert for product improvement that shows in Table 5. The improvement will allow users to understand that different colony colors and color changes occurring on a single selective medium indicate that the growing bacteria belong to different species. For example, *Escherichia coli* grown on EMBA selective media will produce distinctive black colonies with a metallic green sheen, while *Enterobacter sp.* colonies will appear purple (Gita et al., 2021; Nawangsih et al., 2023).

Table 5. Revision based on expert suggestion

Suggestion	Revised version
	
In the previous display, the researcher only included the selective medium where the bacteria could grow	The improvement made was adding a description of the specific colony colors that developed and the color changes on the selective medium

Implementation stage starts after revising to 32 students of 10th grade students at SMAN 20 Gowa regency. The practicality assessment is determined based on the average score from the response questionnaire of 32 students with the response questionnaire and the learning implementation sheet assessed by the biology teacher. The results are presented in Table 6.

Table 6. Practically assessment results

Assessor	Average score (%)	Practically categories
Response of students	88	Highly practical
Response of teacher	100	Highly practical
Learning Implementation sheet	100	Highly practical

Table 7 shows the results of the average pretest and posttest score from students. N-gain score is 0.8 that's mean highly effective. So, this digital infographic is effective for improving student learning outcomes. This results in line with Milala et al. (2022) who stated that effective media are those that can support the achievement of learning objectives.

Table 7. N-gain score results

Average pretest	Average posttest	Maximum score	N-gain score	N-gain categories
49	92	100	0.8	Highly effective

The findings of this study are in line with several previous studies that examined the influence of digital infographic. In previous studies, students find infographics helpful, particularly for understanding and retaining learning material. The infographic is also used as part of teaching strategies (Susanti & Kumalasari, 2022). Other studies also report that infographics are very useful in classes that require students to do a lot of reading. Visual presentations of data can help students become more interested in reading (Mansur & Rafiudin, 2020). Moreover, the effectiveness of digital infographic is in line with other studies that report the impact of contextual learning media in Biology. Contextual biology learning will have an impact on students' cognitive learning outcomes (Nurmiati et al., 2022). Contextual learning connects the material being taught with real-life examples from the students everyday environment, enabling them to easily understand and apply the values and benefits of the learning they acquire while developing relevant skills to face real-world situations (Budiman et al., 2020; Nurmiati et al., 2022; Maftuh, 2023).

Conclusion

This digital Eubacteria infographic is a visual representation of research conducted in the FMIPA UNM laboratory. It illustrates six different types of bacteria identified from the exoskeleton of houseflies, complete with microscopic images and a brief description of each bacterium's characteristics. The infographic is packaged as an application accessible via Android smartphones. The development of digital infographic obtained the results of expert lecturers validation getting highly valid category. The results of the practicality assessment shows highly practical categories. N-gain score shows that the digital infographic is in highly effective categories. So, from all the assessment the researchers make conclusion that the development of digital infographic based on housefly exoskeleton identification bacterial is valid, practical and effective to used by students in Biology learning. This study indicates that the use of contextual learning media can improve students' learning outcomes.

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Conflicts of Interest
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