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The Effect of Archaebacteria and Eubacteria Web-Based Learning Media on Students' Cognitive Learning Outcomes in Balikpapan

AUTHORS INFO

Maulida Ulfa Hidayah
Sultan Aji Muhammad Idris Islamic University Samarinda
maulida.ulfa@uinsi.ac.id
+6281348565152

Muhamad Agil
Sultan Aji Muhammad Idris Islamic University Samarinda
agil88@uinsi.ac.id
+6285643331642

Sonja V. T. Lumowa
University of Mulawarman
verasonja@yahoo.com
+6281356277554

Didimus Tanah Boleng
University of Mulawarman
didimus.tanahboleng@yahoo.com
+6281217525404

Rini Eka Lestari
Sultan Aji Muhammad Idris Islamic University Samarinda
riniekalestari05@gmail.com
+6282287640500

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Abstract

Cognitive learning outcomes are an aspect related to the reasoning or thinking process, namely the ability and activity of the brain to develop rational abilities. Based on observation of schools in Balikpapan, students' cognitive learning outcomes still have not achieved the minimum completion criteria (KKM). Students have difficulties in learning archaebacteria and eubacteria because the concepts are abstract. The lack of variations in learning media has made this topic more difficult to teach. This research aimed to determine the influence of Archaebacteria and Eubacteria web-based learning media on students' cognitive learning outcomes in Balikpapan. The type of research was quasi-experimental with a pretest-posttest control group design. The study population was all senior high schools in Balikpapan. The sampling technique used purposive sampling. The samples of this research were three senior high schools in Balikpapan.

The subjects of this research were students of SMAN 1 Balikpapan, SMAN 2 Balikpapan, and SMA Patra Dharma Balikpapan. Data analysis technique using ANCOVA (SPSS Statistics 23). According to the research findings, the average cognitive learning score of the cognitive learning score test in the experimental class is higher than the control class, which is 72.98 > 67.84. The prerequisite test shows that data were normally distributed and class groups derived from a homogenous population. The hypothesis test using ANCOVA at a 0.05 significance level shows that there is an effect of applying web-based learning media on students' cognitive learning outcomes in learning archaebacteria and eubacteria.

Keywords: *Archaebacteria* and *Eubacteria*, *Cognitive Learning Outcomes, Web-Based Learning Media.*

A. Introduction

Biology education plays a crucial role in introducing students to biodiversity and the fundamental principles of biology, which serve as the foundation for understanding more complex concepts. High biodiversity is a vital and strategic natural wealth that acts as a fundamental asset for national development. Therefore, biodiversity conservation holds a significant role in supporting sustainable development (Nur Tasmiah Sirajuddin, 2024). The introduction of biodiversity to students can be facilitated through the learning process in schools. The learning process serves as an interaction between teachers and students to achieve desired goals and outcomes (Windhasari et al., 2015, S. W. Ulfa et al., 2023).

The success of the learning process inevitably requires various supporting tools, including teaching methods and learning media. Methods are essential efforts to achieve learning objectives, aimed at enhancing teaching effectiveness and personal skills. Therefore, it is crucial to employ effective and appropriate methods to ensure that learning objectives are successfully attained (Anisa et al., 2020). In addition to selecting teaching methods that enhance the learning process, the choice of learning media is also essential for improving student learning outcomes. Appropriate media must be carefully chosen, as it significantly impacts students' level of understanding. This influence can be observed through the results of their cognitive assessments (Zahwa & Syafi'i, 2022). The selection of appropriate teaching methods and learning media is the key to creating an effective and meaningful learning process.

In addition to selecting teaching methods that can enhance the learning process, the selection of appropriate learning media is also necessary to improve student learning outcomes. The choice of suitable media is crucial, as it significantly influences students' level of understanding. This impact can be observed through their cognitive assessment results (Kurniawan, 2015). One of the alternative media for implementing the learning process is the utilization of digital media facilities. Digital learning involves delivering materials in digital formats (e.g., text and images) through the internet or pre-provided learning content (Holzberger et al., 2013, Manurung, 2020). The presence of digital media influences students' learning methods, and its utilization can make the learning process more engaging (Musyoka et al., 2018). The effective utilization of digital media can serve as an innovative solution to enhance the quality of the learning process, strengthen students' understanding, and create a more engaging and interactive learning experience.

One approach to delivering digital learning is through the use of web-based learning media developed by teachers. Web-based learning media can present various interconnections between different lesson materials, making the created media more diverse and comprehensive (Baisa, 2018). The materials presented in web-based learning media take the form of e-learning application systems that can deliver content in a more engaging and up-to-date manner while also enabling interactivity and two-way feedback between teachers and students during the learning process (Haryadi et al., 2021). This approach allows teachers to diversify their teaching methods, enabling students to engage more actively in the learning process by leveraging the sophistication of digital media in the form of web-based learning (Wibowo Hamid Sakti, 2023).

Prior to conducting this study, the researchers reviewed previous studies on the topic of Archaebacteria and Eubacteria. Research conducted by Hidayatussaadah, as quoted from Arisya Widyadhar et al. in the *Journal of Classroom Action Research*, found that 65.3% of 94 subjects and 43.1% of 62 subjects indicated that students did not understand how to explain reproduction in Archaebacteria and Eubacteria. Students found it challenging to understand bacterial reproduction because bacteria reproduce through binary fission, budding, or fragmentation. Students often experienced confusion in distinguishing between binary fission and fragmentation. Similarly, research by Kurniasih and Haka in the same article found that 25% of students did not understand the reproduction of Archaebacteria and Eubacteria, as the material is highly abstract and lacks adequate media support to facilitate learning (Widyadhari et al., 2023). More complex conceptual misunderstandings can hinder the formation of scientific concepts within students' cognitive structures (Suwarto, 2013). Based on the researchers' observations at high schools in Balikpapan, specifically SMAN 1 Balikpapan, SMAN 2 Balikpapan, and SMA Patra Dharma Balikpapan, it was found that students' cognitive scores in Biology, particularly on the topic of Archaebacteria and Eubacteria, had not met the Minimum Competency Criteria (KKM). Students also faced difficulties in understanding the topic due to its abstract concepts and the lack of easily observable visualizations. Additionally, the variety of media used in these schools was neither diverse nor interactive when addressing the topic of Archaebacteria and Eubacteria.

Several researchers have previously conducted studies on web-based learning, including the use of ICT-based learning systems, which have been shown to enhance students' cognitive aspects, as analyzed through cognitive domain assessment indicators. Based on the aforementioned findings, it can be concluded that e-learning with web-based learning is highly effective for improving students' cognitive abilities in the topic of Archaebacteria and Eubacteria (A. W. Ulfa, 2017). Previous studies found a 72.3% increase in students' cognitive abilities when using LKPD-Electronic Liveworksheets for the concept of Archaebacteria and Eubacteria. This aligns with the current research, which also focuses on Archaebacteria and Eubacteria. However, there is a key difference: the previous studies utilized LKPD-Electronic Liveworksheets, while the current research employs web-based learning media (Nada et al., 2022). he novelty of this study lies in (1) comparing web-based learning with regular learning in terms of students' cognitive learning outcomes and (2) focusing on biology content, specifically on the topic of Archaebacteria and Eubacteria. This study's novelty will benefit both face-to-face and distance learning environments, enabling educators to utilize this learning media in their teaching activities.

Research on this topic is essential and necessary to address the challenges of instructional materials that prioritize conceptual understanding in the study of microscopic objects. Based on the aforementioned background, this study aims to examine the impact of web-based learning media on Archaebacteria and Eubacteria on students' cognitive learning outcomes in Balikpapan.

B. Literature Review

1. Web-Based Learning Media

Web-based learning media has become one of the significant innovations in the field of education. The use of this media provides ease of access to information, flexibility in learning schedules, and active student engagement. Web-based learning offers various interactive features such as videos, simulations, and quizzes that support the achievement of learning objectives. According to Gagne et al., (2005), web-based learning media refers to electronic media that utilizes internet technology to deliver learning materials digitally to students. This media enables access to learning content without geographical limitations, making it highly effective for distance learning.

Advantages of Web-Based Learning Media

a. Accessibility: Web-based media allows students to access learning materials anytime and anywhere (Anderson, 2008).
b. Interactivity: According to Mayer (2009), web-based media provides various interactive tools such as discussion forums, simulations, and multimedia that aid students' understanding.
c. Flexibility: Web-based learning offers flexibility in scheduling, making it suitable for students with busy schedules (Means et al., 2013).
d. Cost-Effectiveness: Web-based media is often more economical than traditional learning methods as it reduces the need for printed materials and physical classrooms (Horton, 2011).

Challenges of Web-Based Learning Media

a. Internet Connectivity: Limited internet access in certain regions remains a significant barrier to the implementation of web-based media (Kirkwood & Price, 2014).
b. Student Engagement: The lack of face-to-face interaction can result in some students feeling less motivated or struggling to follow the learning process (Chen et al., 2010).

c. Design and Content: Web-based media requires appealing designs and relevant content to be effective (Ally M, 2008).

Implementation of Web-Based Learning Media in Various Contexts

a. Formal Education: In formal educational institutions, web-based media supports blended learning, where online learning complements face-to-face instruction(Graham, C., 2006).
b. Corporate Training: Companies use web-based media for employee training due to its flexibility and scalability (Clark & Mayer, 2016).
c. Self-Learning: This media is also popular for self-directed learning through platforms such as Coursera and Khan Academy (Bonk & Graham, 2012).

Web-based learning media offers numerous advantages in supporting teaching and learning processes, particularly in the context of modern education. However, challenges such as internet access and content design need to be addressed to ensure optimal implementation. With the proper integration of technology, web-based learning media can be an effective solution for improving the quality of education.

2. Archaebacteria and Eubacteria

Archaebacteria and Eubacteria are two primary groups within the prokaryotic domain, each possessing unique and significant characteristics in ecosystems and biotechnological applications. Their classification is based on fundamental differences in genetic structure, physiology, and chemical composition of their cell membranes. A deep understanding of these two groups is crucial in the fields of microbiology, ecology, and biotechnology.

Archaebacteria are a group of unicellular microorganisms known for their ability to survive in extreme environments, such as hot springs, high salinity areas, and anoxic conditions. Archaebacteria exhibit several unique characteristics:

a. Membrane Composition: The cell membrane of Archaebacteria is composed of ether lipids, distinct from the ester lipids found in Eubacteria and Eukaryota. This composition provides stability in extreme environments. For example, methanogens produce methane in anoxic conditions (Woese et al., 1990).
b. Genome and Metabolism: The genome of Archaebacteria contains elements similar to Eukaryota, such as histone proteins, which are absent in Eubacteria. They also possess unique metabolic pathways, including methanogenesis and chemosynthesis (Garrett & Klenk, 2007).
c. Ecological Role: Archaebacteria play a vital role in biogeochemical cycles, such as the carbon and nitrogen cycles, particularly in extreme environments (DeLong, 1998).

Eubacteria, also known as "true bacteria," are the most commonly found microorganisms in diverse environments. Their main characteristics include:

a. Membrane Composition: Eubacteria have cell membranes consisting of ester lipids and peptidoglycan as the primary component of their cell walls, differentiating them from Archaebacteria (Madigan et al., 2015).
b. Metabolic Diversity: Eubacteria exhibit a wide range of metabolic pathways, including photosynthesis (e.g., Cyanobacteria), aerobic respiration, and anaerobic fermentation. This group is critical in global nutrient cycles (Whitman et al., 1998)..
c. Biotechnological Applications: Many Eubacteria are utilized in biotechnology, such as Escherichia coli in genetic engineering and Bacillus subtilis in industrial enzyme production.

Although both are prokaryotes, Archaebacteria and Eubacteria differ significantly in molecular structure and biochemistry:

a. Cell Walls: Archaebacteria lack peptidoglycan, whereas Eubacteria have peptidoglycan-rich cell walls.
b. Genetics: Archaebacteria share many genetic elements more closely related to Eukaryota than Eubacteria.
c. Habitats: Archaebacteria are predominantly found in extreme environments, whereas Eubacteria are widespread across various habitats, including the human body as part of the microbiota.

Understanding Archaebacteria and Eubacteria provides essential insights into the diversity of prokaryotic life and their roles in global ecosystems. Moreover, these groups offer significant potential in biotechnological innovation, such as the development of extremophile enzymes from Archaebacteria and genetic engineering applications using Eubacteria.

3. Cognitive Learning Outcomes

Cognitive learning outcomes represent a critical aspect of educational evaluation, reflecting students' levels of understanding, knowledge, and intellectual abilities. Cognitive learning outcomes are often used as indicators of the success of the learning process, particularly in formal education. Bloom et al., (1956) categorized cognitive learning outcomes into six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation, which were later revised by Anderson, L. W., & Krathwohl, (2001) into remembering, understanding, applying, analyzing, evaluating, and creating.

Cognitive learning outcomes encompass students' abilities that range from recalling information to higher-order thinking skills such as analysis and evaluation (Anderson, L. W., & Krathwohl, 2001). These abilities reflect the effectiveness of the learning process in enhancing students' knowledge and intellectual skills.

Factors Influencing Cognitive Learning Outcomes:

a. Learning Strategies: Strategies implemented by teachers, such as Project-Based Learning (PBL) or Problem-Based Learning (PBL), can significantly affect students' cognitive learning outcomes (Hmelo-Silver, 2004).
b. Learning Motivation: Both intrinsic and extrinsic motivation play a vital role in determining students' learning success (Deci & Ryan, 2000).
c. Learning Media: The use of learning media such as videos, simulations, or digital platforms can enhance students' engagement and understanding (Mayer, 2009).
d. Environmental Conditions: A conducive learning environment, both physically and psychologically, also contributes to cognitive learning outcomes (Fraser, 2012).

The measurement of cognitive learning outcomes is conducted through tests and evaluations designed to assess students' thinking abilities across various levels. Bloom's Taxonomy is frequently utilized as a framework for designing evaluation instruments, such as multiple-choice questions or essays, which reflect specific cognitive levels (Anderson, L. W., & Krathwohl, 2001).

Improving Cognitive Learning Outcomes:

a. Active learning methods, such as group discussions and simulations, increase student engagement in the learning process (Prince, 2004).
b. Feedback: Timely and constructive feedback can help students understand their strengths and weaknesses, thereby enhancing cognitive learning outcomes (Hattie & Timperley, 2007).
c. Technology Integration: Educational technology, such as online learning platforms and interactive tools, has been shown to improve cognitive learning outcomes by creating more engaging and personalized learning experiences. Online learning with an actively integrated and collaborative approach, including the use of features such as interactive videos, further enhances the general effectiveness of learning compared to traditional face-to-face methods. Additionally, blended learning is considered more effective as it provides extended study time and fosters additional opportunities for interaction between students and learning materials (Means et al., 2013).

Cognitive learning outcomes are a vital component of education, reflecting the success of the learning process. Factors such as learning strategies, motivation, media, and the learning environment greatly influence these outcomes. To improve cognitive learning outcomes, innovative teaching approaches and the appropriate use of technology are essential.

C. Methodology

1. Research Design

This study employed a quasi-experimental design with a pretest-posttest control group design. This approach was used to examine the effects of a treatment by comparing differences in cognitive learning outcomes between two groups: the experimental group (students using web-based learning media) and the control group (students using traditional teaching methods provided by the teacher or without web-based learning media). The study was conducted at senior high schools in Balikpapan. The sample selection was based on criteria that the senior high schools are located in Balikpapan, have an A accreditation, provide good internet access facilities, and ensure that these facilities can be utilized effectively in the learning process by both teachers and students. The sample consisted of three schools: SMAN 1 Balikpapan, SMAN 2 Balikpapan, and SMA Patra Dharma Balikpapan. The research subjects included students from each school. The experimental group comprised 34 students from SMAN 1 Balikpapan, 18 students from SMAN 2 Balikpapan, and 22 students from SMA Patra Dharma Balikpapan, totaling 74 students. The control group included 34 students from SMAN 1 Balikpapan, 18 students from SMAN 2 Balikpapan, and 20 students from SMA Patra Dharma Balikpapan, totaling 72 students.

The research design follows a pre-experimental design with a pretest-posttest control group format, as shown in Table 1

Table 1. Design follows a pre-experimental design with a pretest-posttest control group

Group	Pretest	Treatment	Posttest
Experimental Class	O_1	X_1	O_2
Control Class	O_3	X_2	O_4

Description:

O_1 and O_3 : Pretest in the experimental class and pretest in the control class

O_2 and O_4 : Posttest in the experimental class and posttest in the control class

X_1 : Learning using web-based learning media on Archaebacteria and Eubacteria

X_2 : Learning using conventional teaching methods provided by the teacher

Table 1 presents the research design comparing the pretest-posttest class groups with the implementation of their respective learning methods.

The population in this study comprised 20 senior high schools (SMA) in Balikpapan. The sampling technique used was purposive sampling. The criteria for selecting the sample included schools that: (1) had accreditation at the time of the study, (2) provided Wi-Fi facilities accessible to students during school learning, (3) had separate laboratories for chemistry, biology, and physics, (4) had not previously implemented web-based learning in biology, and (5) showed consistent academic achievements over the past five years. The selected sample schools were SMAN 1 Balikpapan, SMAN 2 Balikpapan, and SMA Patra Dharma Balikpapan. The details of the subjects are as follows: SMA Patra Dharma Balikpapan included an experimental class with 22 students (X MIPA 4) and a control class with 20 students (X MIPA 5). SMAN 1 Balikpapan included an experimental class with 34 students (X MIPA 4) and a control class with 34 students (X MIPA 3). SMAN 2 Balikpapan included an experimental class with 18 students (X MIPA 6) and a control class with 18 students (X MIPA 3). In total, there were 74 students in the experimental classes and 72 students in the control classes. The selection of these classes as research samples was based on the consideration that the experimental classes in each school exhibited similar abilities to those in other schools.

2. Instrumens

The research instruments consisted of observation, interviews, documentation, and tests. Observation was conducted to examine the implementation of teaching and learning activities during the Archaebacteria and Eubacteria lessons. The interview sheet included a set of questions for teachers, focusing on their teaching activities, teaching resources, instructional media, the subjects of Archaebacteria and Eubacteria, and the development of learning media applied in the teaching process. Documentation was used to obtain reports on students' learning outcomes and daily grades related to Archaebacteria and Eubacteria. The test instrument was employed to measure students' cognitive learning outcomes on the topic of Archaebacteria and Eubacteria. The data obtained from these instruments were descriptive quantitative data.

The test consisted of cognitive assessment questions in the form of 9 essay questions. The outline and examples of the questions used can be seen in Table 2. The validity test of the instrument was conducted using the Pearson product-moment correlation, and the reliability test was performed using the Cronbach's Alpha formula with the assistance of SPSS software version 23.0. Based on the results of the validity and reliability calculations of the learning outcome assessment instruments, it can be concluded that the research instruments are valid and reliable.

Table 2. Question Table

Indicator		Question	Cognitive Level
Identifying characteristics of bacteria and bacterial classification	1.	Create a comparison table of the characteristics of Archaebacteria and Eubacteria!	C4
	2.	Write a brief summary of the classification of Archaebacteria!	
	3.	Write a brief summary of the classification of Eubacteria!	
	4.	Observe and complete the diagram of bacterial structures by explaining the functions of their organelles!	
Identifying bacterial reproduction	5.	Observe and complete the diagram of bacterial asexual reproduction and provide an explanation!	C4
	6.	Observe and complete the diagram of three types of bacterial sexual reproduction and provide an explanation!	
Identifying bacterial observation	7.	What are the steps involved in bacterial observation?	C3
	8.	How does the observation of bacteria relate to bacterial classification?	C4
Identifying the roles of bacteria	9.	Can pathogenic bacteria play a positive role in human life? Provide reasons and give two examples of such bacteria!	C4

3. Technique of Data Analysis

The problem identification began with direct observation of the school conditions at several senior high schools in Balikpapan. Observations focused on students and the learning process, as well as determining the research population and sample. The observations revealed issues with learning media, prompting the researchers to develop research instruments and conduct validity and reliability tests. The implementation phase involved teaching the experimental class using validated web-based learning media on *Archaebacteria* and *Eubacteria*. Meanwhile, the control class was taught using conventional teaching methods delivered by the teacher.

The learning process was conducted following a Lesson Plan (RPP) based on the syllabus, where the subject matter focused on *Archaebacteria* and *Eubacteria*. At the end of the session, students were given a learning outcome test to assess their cognitive understanding of the material. The research procedure is illustrated in Figure 1.

The pretest and posttest results from all classes were analyzed using statistical tests. The analyzed data included pretest and posttest scores. The prerequisites for data analysis were tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests for normality and Levene's test for homogeneity. Additionally, ANCOVA was employed to test the hypothesis and determine whether the implementation of web-based learning media on *Archaebacteria* and *Eubacteria* had an effect on students' cognitive learning outcomes in Balikpapan. The hypothesis testing involved two initial possibilities: acceptance or rejection. All analyses were performed using SPSS version 23.0 for Windows.

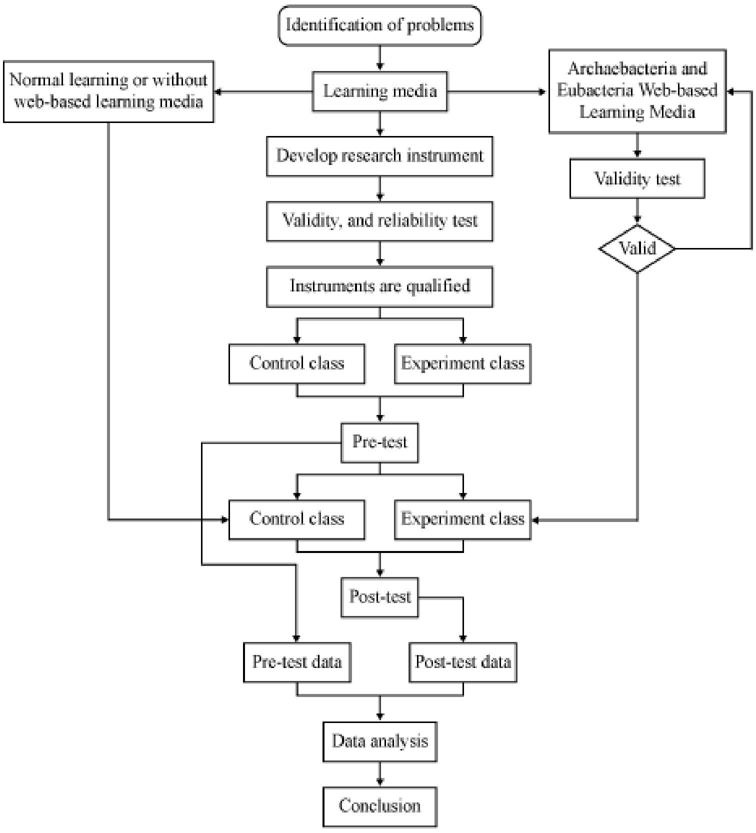

Figure 1. Research Procedure

D. Findings and Discussion

1. *Findings*

The study in the experimental and control classes was conducted to examine changes in cognitive learning outcomes using pretest and posttest evaluations. The data were analyzed using ANCOVA with SPSS software version 23.0. Prior to performing the ANCOVA test, prerequisite tests were conducted. These included a residual normality test for posttest data using the Kolmogorov-Smirnov and Shapiro-Wilk tests, as well as a homogeneity of variance test using Levene's test. Initial data processing was carried out to test the normality and homogeneity of the data at a significance level of 0.05. The results of the data analysis indicated that the data were normally distributed (p-value = 0.2 > 0.05) as shown in Table 2. Furthermore, the homogeneity test using Levene's test showed that the data were homogeneous (p-value = 0.94 > 0.05) as presented in Table 3.

Table 3 Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Residual Untuk Posttest	.058	146	.200*	.977	146	.016

Table 4 Homogeneity Test

F	df1	df2	Sig.
1.108	1	144	.294

The results of the normality test in Table 3 indicate that (p-value = 0.2 > 0.05), meaning the data are normally distributed. Meanwhile, Table 4 shows that (p-value = 0.94 > 0.05), indicating that the data are homogeneous. Therefore, the data are deemed suitable for further analysis using ANCOVA to determine whether the implementation of web-based learning media on *Archaebacteria* and *Eubacteria* affects students' cognitive learning outcomes.

The results of the normality and homogeneity tests confirm that the data meet the requirements for ANCOVA testing. This analysis will examine the influence of web-based learning media on *Archaebacteria* and *Eubacteria* on students' cognitive learning outcomes. A summary of the ANCOVA analysis is presented in Table 5.

Table 5 ANCOVA Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16097.077[a]	2	8048.538	70.907	.000
Intercept	8679.818	1	8679.818	76.469	.000
Pretest	15177.611	1	15177.611	133.714	.000
Kelas	962.127	1	962.127	8.476	.004
Error	16231.699	143	113.508		
Total	756892.938	146			
Corrected Total	32328.776	145			

a. R Squared = .498 (Adjusted R Squared = .491)

Based on Table 5, it can be explained that the F-value = 133.714 with a significance level of 0.000 ($p < 0.05$) indicates a significant difference in students' cognitive learning outcomes between the experimental and control classes. Additionally, the implementation of web-based learning media on *Archaebacteria* and *Eubacteria* shows a significant difference in students' cognitive learning outcomes, as indicated by an F-value = 8.476 with a significance level of 0.004 ($p < 0.05$) based on the effect test. Further analysis was conducted to examine the mean score differences between the experimental and control classes, as presented in Table 5.

Table 6 Comparison of Mean Cognitive Learning Outcomes Between the Experimental and Control Classes

Class	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	67.844[a]	1.256	65.362	70.326
Experiment	72.979[a]	1.239	70.531	75.427

Table 6 shows that the mean cognitive learning outcome of students in the experimental class was 72.979, while in the control class it was 67.844. These results indicate that the implementation of web-based learning media on *Archaebacteria* and *Eubacteria* had a more positive effect on the cognitive learning outcomes of students in the experimental class compared to the control class.

2. *Discussion*

The appropriate selection of media in the learning process greatly influences students' understanding, as reflected in their cognitive assessment results (Kurniawan, 2015;Subekti & Siswandari, 2024) . The use of e-learning media in learning processes has been shown to improve students' cognitive outcomes (Delvia & Fauziah, 2022). Web-based learning media facilitate the presentation of content and assignments, enabling open interactions between teachers and students. This environment makes it easier for students to understand the material presented and enhances their cognitive abilities (Rahayu, 2018). Additionally, web-based e-learning media are often regarded as high-quality educational tools (Priyambodo et al., 2012;Sutama & Fajriani, 2022).

Learning materials packaged in web-based learning media represent a form of e-learning application that not only delivers more engaging and up-to-date content but also incorporates interactivity and feedback between teachers and students. This allows teachers to implement more diverse teaching methods while encouraging students to actively participate in learning (Zahara, 2023). These findings support the conclusion that web-based learning media positively affect cognitive learning outcomes, particularly for topics such as Archaebacteria and Eubacteria. The use of appropriate web-based media for teaching Archaebacteria and Eubacteria allows students to explore more information independently and engage in problem-solving activities that can be revisited through available web pages. The high quality of the developed web-based learning media further contributes to improving students' conceptual understanding, as reflected in their cognitive outcomes.

The improved average cognitive learning outcomes in the experimental class, compared to the control class, are supported by the higher percentage increase in students' cognitive scores in the experimental group. Hanum (2013) highlights that the content presented in web-based learning media is one form of e-learning application capable of delivering more engaging and up-to-date materials, fostering interactivity and feedback between teachers and students. This diversity in teaching approaches allows students to be more active in their learning process. Similarly, research by (Arifin & Herman, 2018) who stated that e-learning media can foster students' independence in learning, as it is equipped with text, images, animations, and provides ease for group discussions while enhancing student engagement. E-learning also influences students' conceptual understanding and learning independence due to its attractive presentation.

Web-based learning media on Archaebacteria and Eubacteria encourage students to be more independent in their learning. These media are easily accessible and allow students to construct their knowledge independently, guided by teachers, thus fostering interactive learning. Arifin & Herman, (2018) emphasize that e-learning media also promote students' independence in learning Novialdi et al., (2020) further support this, stating that web-based learning enhances students' conceptual mastery, enabling them to independently construct their knowledge. Baisa (2018) adds that the use of web-based media fosters active and enjoyable learning for students, with its varied and engaging features stimulating students' cognitive abilities and facilitating better and quicker comprehension of the material.

Web-based learning materials, designed by teachers using various resources such as the internet and books, simplify the presentation of content tailored to the conditions and needs of the students. Hidayah et al. (2020) affirm that web-based learning media are applicable for teaching Biology topics, specifically Archaebacteria and Eubacteria. These media can serve as engaging teaching resources, presenting content through text, images, animations, exercises, glossaries, sound, and videos enhanced with background music and captions. Hidayah et al. (2018) further note that multimedia-packed web-based materials increase student interest during classroom learning and improve learning outcomes by simplifying complex content. Teachers can utilize such media to enhance the learning process for Archaebacteria and Eubacteria, tailoring the content to the specific needs and conditions of their students.

The higher average cognitive learning outcomes in the experimental class compared to the control class are attributed to differences in learning motivation. The interactive nature of the web-based media used in the experimental class influenced students' cognitive outcomes. This aligns with Priyambodo et al., (2012) who found that student motivation increased by 3.5% when interactive web-based media were utilized during the learning process.

However, not all web-based learning is suitable for every student, as it depends on the diverse characteristics of the learners Self-motivation, including the need for learning materials and persistence during the learning process, is a key factor in the success of web-based learning. Students tend to have a greater need for learning materials as they approach the end of a semester or graduation, making any teaching method more effective when applied in such contexts. Furthermore, Suparman (2017) and Said Zulfikar, (2021) highlights that adequate computer equipment and internet connectivity are crucial factors in the success of web-based learning.

E. Conclusion

Based on the discussion of the research results, it can be concluded that there is an effect of web-based learning media on Archaebacteria and Eubacteria on students' cognitive learning outcomes in Balikpapan. There is a significant difference in cognitive learning outcomes between the experimental and control classes. The experimental class, which used web-based learning media on Archaebacteria and Eubacteria, demonstrated better cognitive learning outcomes compared to the control class, which relied solely on conventional learning methods. The findings revealed that the cognitive learning outcomes in the control class without the use of web-based learning media had an average score of 67.844. In contrast, the experimental class utilizing the web-based learning media achieved an average score of 72.979. Hypothesis testing using ANCOVA at a significance level of 0.05 indicated that the implementation of web-based learning media significantly impacted students' cognitive learning outcomes in studying Archaebacteria and Eubacteria. Based on these findings, Educators should incorporate web-based learning media featuring interactive elements such as quizzes, animations, and forums to effectively teach abstract topics like Archaebacteria and Eubacteria. Additionally, schools should invest in the necessary infrastructure, such as reliable internet access and teacher training programs, to maximize the benefits of such media.

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