**Journal of Academic Biology and Biology Education**
Vol. 1, No. 2, December 2024, pp. 177~185
ISSN: 3062-9705, DOI: 10.37251/jouabe.v1i2.3178


# The Effect of Using Offline Web-Based Interactive Multimedia on Students' Biology Learning Outcomes

**Rosana[1], Abu Darda[2], Zaenudin[3]**
[1]Department of Biology Education, Natural Science Education, Syarif Hidayatullah State Islamic University of Jakarta, Banten, Indonesia
[2,3]Biology Teacher, State Senior High School 1 Tarumajaya Bekasi, West Java, Indonesia

**Article Info**

***Article history:***

Received Oct 31, 2024
Revised Nov 30, 2024
Accepted Dec 27, 2024
Online First Dec 28, 2024

***Keywords:***

Biology Learning Outcomes
Digestive System
Digital Learning
Interactive Multimedia
Offline Web

**ABSTRACT**

**Purpose of the study:** This study aims to determine the effect of offline web-based interactive multimedia on students' biology learning outcomes in the human and ruminant digestive systems. The study also aims to compare the effectiveness of this media with conventional learning media in the form of presentation slides.

**Methodology:** The study used a quasi-experimental method with a two-group pretest-posttest design. The sample was selected using cluster random sampling. The research instrument was a multiple-choice biology learning outcome test. Data analysis used the Chi-square test, Fisher's exact test, and the t-test. Data processing was performed using Microsoft Excel and the Statistical Package for the Social Sciences software.

**Main Findings:** The results showed that the pretest and posttest data were normally distributed and homogeneous. There was no significant difference in pretest scores between the experimental and control groups. There was a significant difference in posttest scores between the two groups. The group using offline web-based interactive multimedia achieved higher learning outcomes than the group using presentation slides. This medium has been proven effective in improving students' biology learning outcomes.

**Novelty/Originality of this study:** The novelty of this research lies in the application of offline web-based interactive multimedia to biology learning, specifically the concept of the human and ruminant digestive systems. This research provides an innovative alternative digital learning media that can be used without an internet connection, thereby expanding the use of educational technology and adding empirical references regarding the effectiveness of interactive media in improving student learning outcomes.



***Corresponding Author:***
Rosana
Department of Biology Education, Natural Science Education, Syarif Hidayatullah State Islamic University of Jakarta, Jl. Ir. H. Djuanda No. 95, Ciputat, East Ciputat District, South Tangerang City, Banten 15412, Indonesia.
Email: anarosnaana@gmail.com

## 1. INTRODUCTION

The development of information technology has brought about significant changes in the world of education, particularly in the learning process in schools [1], [2]. The use of technology allows the delivery of learning materials to be more engaging, interactive, and easily understood by students [3], [4]. One example of

this technology is the use of interactive multimedia in teaching and learning activities. Interactive multimedia can combine elements of text, images, animation, audio, and video in a single learning medium [5], [6]. This media presence provides teachers with the opportunity to create more effective and student-centered learning.

Biology learning is a field of study that demands a deep understanding of concepts [7], [8]. Much biology material is abstract and complex, making it difficult for students to grasp if presented solely through lectures. One topic often considered difficult is the concept of the human and ruminant digestive systems [9], [10]. This material covers biological processes involving various interconnected organs and mechanisms. Therefore, learning media that can visualize these concepts clearly and systematically are needed [11], [12].

The use of appropriate learning media can increase student engagement in the learning process [13], [14]. To date, biology learning in many schools is still dominated by textbooks and conventional explanations [15], [16]. This often results in students being less active and having difficulty optimally understanding the material. The lack of variety in learning media can also reduce students' interest in biology [17], [18]. As a result, their learning outcomes do not reach the expected level.

Offline web-based interactive multimedia offers an innovative and practical alternative to learning media [19], [20]. This media can be accessed without an internet connection, making it more flexible for use in various school settings. Through interactive displays, students can learn independently by exploring the material according to their needs [21], [22]. Engaging visualization features enable students to understand biological processes more concretely. Thus, offline web-based interactive multimedia has the potential to increase the effectiveness of biology learning.

Student learning outcomes are influenced by various factors, one of which is the use of learning media that are appropriate to the characteristics of the material [23], [24]. Interactive media can stimulate students' attention and increase their learning motivation. When students are actively involved in the learning process, conceptual understanding tends to improve [25], [26]. This positively impacts students' ability to remember, understand, and apply the material they have learned. Therefore, the use of interactive multimedia requires further study to determine its effectiveness on biology learning outcomes [27], [28].

Various previous studies have shown that the use of interactive multimedia can improve student learning outcomes in various subjects [29], [30]. However, most research still focuses on online-based multimedia, which relies on internet access. Furthermore, there is limited research specifically examining the effectiveness of offline web-based interactive multimedia in biology learning, particularly on concepts of the human and ruminant digestive systems. This situation indicates a research gap that requires further study. Furthermore, there are still few studies that integrate easy offline access with interactive visualizations in complex biology material.

The novelty of this research lies in the use of offline web-based interactive multimedia as a biology learning medium for concepts of the human and ruminant digestive systems. This research is important because it offers a digital learning solution that can be implemented without reliance on an internet connection, making it relevant to schools with limited technological facilities. The urgency of this research is heightened given the need for innovative learning media to improve student learning outcomes in abstract and complex biology material. The results are expected to contribute to the development of technology-based biology learning strategies. Therefore, the main objective of this study is to determine the effect of offline web-based interactive multimedia on students' biology learning outcomes in concepts of the human and ruminant digestive systems.

## 2. RESEARCH METHOD

### 2.1. Research Methods and Design

This study employed a quasi-experimental method because it was conducted in a classroom setting, preventing the researcher from randomly grouping subjects [31], [32]. This method was chosen to achieve maximum control over the research variables, reflecting the conditions in the field. This approach aims to approximate actual experimental conditions, even though not all variables can be fully controlled. Thus, the study can still provide an objective picture of the effects of the treatment.

The study involved two groups: an experimental group and a control group. The experimental group received treatment using offline web-based interactive multimedia, while the control group received learning media in the form of presentation slides. A comparison of the two groups was conducted to determine differences in learning outcomes after the treatment [33]. This design allows for a more measurable analysis of the effectiveness of interactive multimedia use.

The research design used a two-group pretest and posttest (Two Group Pretest-Posttest Design). In this design, both groups were first given a pretest to determine students' initial abilities. Next, the experimental and control groups were given different treatments based on the learning media used. After the learning process was completed, both groups were given a posttest to measure learning outcomes. The pretest and posttest results were then compared to determine the effect of offline web-based interactive multimedia on students' biology learning outcomes. The research design is shown in the Table 1.

Table 1. Research Design

| Class | Pretest | Treatment | Posttest |
|---|---|---|---|
| Experiment | $Y_1$ | $X_A$ | $Y_2$ |
| Control | $Y_2$ | $X_B$ | $Y_2$ |

Based on the research design above, both groups were given the same pretest. After being given different treatments, both groups were given the same posttest. The results of both posttests were compared (tested for differences), as were the results of the pretest and the posttest for each group. A significant difference between the two posttests in the experimental group indicates the effect of the treatment.

### 2.2. Population and Sample

The population in this study was all students at Tarumajaya 1 State Senior High School, Bekasi, enrolled in the even semester of the current academic year. This population was selected because it met the research needs, which focused on biology learning at the senior high school level. All students in the population had characteristics relevant to the research objectives. Therefore, this population was considered representative for examining the effect of offline web-based interactive multimedia use on student learning outcomes. Sampling was conducted using a cluster random sampling technique, which selects samples based on randomly selected classes [34]. From the available classes, two classes were determined as research groups. One class was designated as the experimental group receiving learning using offline web-based interactive multimedia, while the other class was designated as the control group using presentation media. Random selection was carried out to minimize bias in group determination. With this technique, the obtained sample is expected to represent the characteristics of the research population.

### 2.3. Data Collection Techniques

The data collection technique in this study was conducted using a learning outcome test developed by the researcher. The test instrument was first tested to determine its validity and reliability before being used in the study. This was done to ensure the instrument could accurately and consistently measure student learning outcomes. The research instruments consisted of a pre-test and a post-test, administered to all study subjects. The pre-test was administered before the learning process began to determine students' initial abilities in the material to be studied. After the entire learning series was completed, students were given a post-test to measure improvements in learning outcomes following the treatment. The instruments used in the pre-test and post-test were of the same format and level of difficulty. A comparison of the results of these two tests was used as a basis for determining the effect of offline web-based interactive multimedia on students' biology learning outcomes.

### 2.4. Research Instruments

The instrument used in this study was a biology learning outcome test. This instrument aims to measure students' mastery of the learning material provided. The test format used was a written test in the form of multiple-choice questions on the concept of the human and ruminant digestive systems [35]. This test format was chosen because it was considered effective in objectively measuring students' conceptual understanding. The preparation of the research instrument was carried out in several stages. The first stage was to determine the concept and subconcepts of the material based on the applicable curriculum. Next, an instrument outline was prepared as a guideline for creating questions. After that, the questions were arranged according to the predetermined indicators and consulted with the supervisor for input and improvements. The final stage was a trial of the instrument to determine the quality of the questions before being used in the study. The instrument outline used in this study is as follows:

Table 2. Research Instrument Grid for Learning Outcome Test

| No. | Learning Indicators | Sub Concept | Question Number | | | | Amount |
|---|---|---|---|---|---|---|---|
| | | | C1 | C2 | C3 | C4 | |
| 1. | Explain the digestive tract and glands that make up the human digestive system. | Digestive tract and glands in humans | 5 | 3,4,7 | | | 4 |
| 2. | Identify the structure and function of the human digestive organs. | Human digestive organs | 6 | 1 | 10 | | 3 |
| 3. | Explain the function of human food and the beneficial substances it contains. | Food substances | 9,12,13 | | | 2,8 | 5 |
| 4. | Explain various examples of disorders and prevention of diseases that occur in the digestive tract. | Diseases and disorders of the digestive system | 14 | | 11,16,17 | 15 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. | Explain the digestive organs and digestive processes in ruminant animals. | The digestive system in ruminant animals | | 18 | | 19,20 | 3 |
| | Amount | | 6 | 5 | 4 | 5 | 20 |

### 2.5. Data Analysis Techniques

The data obtained through the research instruments were analyzed to answer the research problem formulation and test the research hypotheses. Prior to hypothesis testing, prerequisite analysis tests were conducted, including normality and homogeneity tests. These prerequisite tests aimed to determine whether the data were normally distributed and had homogeneous variance. The results of the prerequisite tests formed the basis for determining the statistical techniques used in the hypothesis testing phase.

Normality testing was conducted using the chi-square test to determine whether the research data were normally distributed. The test criteria were that if the calculated chi-square value was less than the table chi-square, the data were considered normally distributed [36]. Once the data were deemed normal, a homogeneity test was conducted using the Fisher exact test. This test aimed to determine the equality of variance between the experimental and control groups. If the calculated F value was less than the table F value, the two groups were considered homogeneous.

After all analysis requirements were met, the hypothesis testing was conducted using the t-test. This test was used to determine whether there were differences in learning outcomes between the experimental group using offline web-based interactive multimedia and the control group using presentation media. Testing was conducted on the results of the pre-test and post-test for both groups. Test decisions are determined based on a comparison between the calculated t-value and the t-table value at a predetermined significance level. The results of this analysis are used to determine the effect of offline web-based interactive multimedia on students' biology learning outcomes.

## 3. RESULTS AND DISCUSSION

### 3.1. Testing Data Analysis Prerequisites

Once the research data is obtained, it will be processed through hypothesis testing. Prior to conducting the hypothesis testing, prerequisite data analysis tests, namely normality and homogeneity tests, are conducted to determine whether the data obtained is normally distributed and has a homogeneous variance. The results obtained after conducting the prerequisite data analysis tests are as follows:

#### 3.1.1. Pretest and Posttest Normality Test

In this study, a normality test was conducted using the Chi-Square test to determine whether the research data were normally distributed. Data were declared normally distributed if the calculated chi-square value was less than or equal to the table chi-square at the specified significance and confidence levels [37]. This test was conducted on the pre-test and post-test data in both research groups. The results of the normality test were used as a basis for determining the feasibility of using parametric statistical analysis in the next stage. The results of the pre-test and post-test normality tests for both research samples are presented in Table 3 below.

Table 3. Results of the Pretest-Posttest Normality Test

| Statistics | Experiment | | Control | |
|---|---|---|---|---|
| | Pretest | Posttest | Pretest | Posttest |
| N | 35 | 35 | 35 | 35 |
| $\bar{X}$ | 36.83 | 75.11 | 29.53 | 66.17 |
| S | 10.37 | 10.38 | 11.37 | 8.44 |
| $X^2_{count}$ | 9.5859 | 4.3135 | 8.5934 | 6.8742 |
| $X^2_{table}$ | 11.070 | 12.592 | 12.592 | 11.07 |
| Conclusion | Normal | Normal | Normal | Normal |

Based on Table 3, it can be concluded that the initial and final test data for both the experimental and control groups are normally distributed. This is indicated by the calculated chi-square value being less than or equal to the table chi-square value. By fulfilling these requirements, the data are deemed to meet the assumption of normality. Therefore, parametric statistical analysis can proceed to the next stage.

#### 3.1.2. Pretest-Posttest Homogeneity Test

After both groups of research samples were declared normally distributed, the next step was to conduct a homogeneity test. This test aims to determine whether the data variances in both groups are similar or homogeneous. In this study, the homogeneity test was conducted using the Fisher exact test. Data are considered

homogeneous if the calculated F value is less than or equal to the table F value at a significance level of 0.05. The results of the homogeneity test for both groups of research samples are presented in Table 4 below.

Table 4. Results of the Pretest – Posttest Homogeneity Test

| Statistics | Pretest | | Posttest | |
|---|---|---|---|---|
| | Control | Experiment | Control | Experiment |
| $S^2$ | 129.228 | 107.543 | 71.2 | 107.6444 |
| $F_{count}$ | 1.2016 | | 1.5119 | |
| $F_{table}$ | 1.7571 | | 1.7571 | |
| | Homogen | | Homogen | |

Homogeneity testing was conducted at a 95 percent confidence level with a significance level of 0.05 and degrees of freedom for each group of 35. Based on the results in Table 4.4, it can be concluded that the initial and final test data for both the experimental and control groups come from a homogeneous population. This is indicated by the calculated F value being smaller or equal to the F table according to the testing criteria. Thus, both groups have equal variances and are suitable for further hypothesis testing.

### 3.2. Hypothesis Testing

After conducting the analysis prerequisite test, it turns out that the data obtained meets the requirements, namely the data is normally distributed in both the control and experimental groups, then its homogeneity is also met because both samples are calculated to be included in the homogeneous sample criteria. Thus, the hypothesis testing using the established formula, namely the t-test, can be continued.

#### 3.2.1. Test of Equality of Two Pretest Means

Hypothesis testing was conducted to determine whether there was a significant difference between the initial test scores of the experimental and control groups. This test used a t-test at a 95 percent confidence level. The null hypothesis is accepted if the calculated t-value is between the negative t-table value and the t-table value, while the alternative hypothesis is accepted if the calculated t-value is outside that range. This test aims to ensure that the initial abilities of both groups are at an equivalent level before being given treatment. The results of the hypothesis testing on the initial test scores of both groups are presented in Table 5 below.

Table 5. Results of the Equality Test of Two Averages of the Pretest Results of the Control and Experimental Groups

| Statistics | Control | Experiment |
|---|---|---|
| N | 36 | 36 |
| $\bar{X}$ | 29.528 | 26.833 |
| $S^2$ | 129.228 | 107.543 |
| $S_{combination}$ | 10.881 | |
| $t_{count}$ | 1.032 | |
| $t_{table}$ | 1.667 | |
| Comparison | $-1.667 < 1.032 < 1.667$ | |
| Results | $t_{count} < t_{table} = H_0$ accepted and $H_a$ rejected | |

Based on Table 5, it can be seen that there is no significant difference between the average initial test scores in the control group and the experimental group. The results of the t-test calculation show that the calculated t value of the initial test is smaller than the t table value at the 95 percent confidence level. This condition indicates that the null hypothesis is accepted according to the established testing criteria. Thus, the initial abilities of students in both groups can be stated as equivalent before being given the learning treatment. This equivalence indicates that both groups have comparable initial conditions for use in the study.

#### 3.2.2. Test of Equality of Two Posttest Means

Hypothesis testing was conducted to determine whether there was a significant difference between the final test scores of the experimental and control groups. This test used a t-test at a 95 percent confidence level. The null hypothesis is accepted if the calculated t value is between the negative t table value and the t table value, while the alternative hypothesis is accepted if the calculated t value is outside that range. This test aims to determine the effect of the learning treatment provided on student learning outcomes. The results of the hypothesis testing on the final test scores of the two groups are presented in Table 6 below.

Table 6. Results of the Equality Test of Two Posttest Means for the Control and Experimental Groups

| Statistics | Control | Experiment |
|---|---|---|
| N | 36 | 36 |
| $\bar{X}$ | 66.167 | 75.111 |
| $S^2$ | 71.2 | 107.6444 |
| $S_{combination}$ | 9.456 | |
| $t_{count}$ | 3.964 | |
| $t_{table}$ | 1.667 | |
| Comparison | 3.964 > 1.667 | |
| Results | $t_{count} > t_{table}$ = $H_0$ rejected and $H_a$ accepted | |

Based on Table 6, the results of the t-test calculation show that the calculated t value of the final test is greater than the t value at a 95 percent confidence level. In accordance with the testing criteria, this condition indicates that the null hypothesis is rejected and the alternative hypothesis is accepted. Thus, there is a significant difference between the average final test scores of the control group and the experimental group. These results indicate that learning using offline web-based interactive multimedia has an impact on student learning outcomes. Therefore, it can be concluded that the use of offline web-based interactive multimedia is more effective than the use of presentation media in improving student biology learning outcomes.

The use of offline, web-based interactive multimedia in biology learning demonstrates that integrating digital technology can be an effective strategy to support the learning process for complex and abstract material. The human and ruminant digestive system requires strong visualization skills to enable students to understand the interrelationships between organs and the systematic biological processes that occur. The presence of interactive multimedia allows for a more concrete presentation of material through a combination of text, images, animations, and interactive navigation, helping students develop a deeper conceptual understanding [38]. This reinforces the view that utilizing learning media appropriate to the material's characteristics contributes to improving the quality of the learning process.

Pedagogically, the effectiveness of interactive multimedia lies not only in its visualization aspect but also in its ability to create more student-centered learning [39], [40]. Offline, web-based media provides opportunities for students to explore the material independently, adjust their learning pace to their individual abilities, and repeat sections as needed. This encourages active learning, which has the potential to increase student cognitive engagement. In the context of biology learning, active engagement is crucial because conceptual understanding is not achieved through memorization alone; it requires elaboration and linking biological concepts [41], [42].

This research also demonstrates that the use of learning technology does not always have to rely on internet connectivity. In many educational contexts in Indonesia, limited network access remains a major obstacle to implementing digital learning. Therefore, the development of offline web-based multimedia is a relevant solution because it can deliver digital learning experiences without requiring stable internet infrastructure [43], [44]. These findings provide the perspective that digital education innovations should be tailored to real-world school conditions to ensure more inclusive and applicable implementation.

From a learning development perspective, the results of this study emphasize the importance of media innovations that are not only visually appealing but also designed based on learning needs. The success of interactive media is influenced by the quality of instructional design, the alignment of content with the curriculum, and ease of use by both students and teachers [45]. Therefore, the development of digital learning media must consider strong pedagogical principles so that technology truly functions as a learning facilitation tool, not simply a visual complement to learning.

This research also provides theoretical contributions to the study of educational technology, particularly in the context of biology learning at the secondary school level. To date, most research has focused on online-based media that require internet network support. This study broadens the scope of this study by demonstrating that offline web-based media also has significant potential to enhance learning effectiveness. Therefore, this research enriches the alternative approaches to developing digital media that are adaptive to various educational conditions.

This research has significant practical implications for education, particularly in the development of biology learning media. The results can serve as a reference for teachers in selecting and developing more innovative learning media to improve the quality of classroom learning. The implementation of offline web-based interactive multimedia can also be a real solution for schools with limited internet access, making it easier to achieve equitable use of educational technology.

Furthermore, this research impacts the development of educators' digital competencies. Teachers are encouraged to be more creative in utilizing available technology to create engaging and effective learning. In the long term, the implementation of this type of media can improve students' digital literacy, strengthen independent learning skills, and foster a learning culture that is more adaptive to developments in educational

technology. Despite its important contribution, this study has limitations: it was conducted in only one school with a limited sample size. Therefore, generalizing the results to a wider population requires caution. Different student characteristics, learning environments, and school facilities can influence the effectiveness of interactive multimedia use.

## 4. CONCLUSION

Based on the research results and data analysis, it can be concluded that learning using offline web-based interactive media has a positive effect on students' biology learning outcomes. This can be seen from the results of the t-test calculation, which obtained a calculated t value of 3.964, and a t table value of 1.667, which means the alternative hypothesis ($H_a$) is accepted and the null hypothesis ($H_0$) is rejected. Future research can examine the influence of using offline web-based interactive multimedia on other aspects of learning, such as learning motivation, critical thinking skills, long-term concept retention, and students' problem-solving skills.

## ACKNOWLEDGEMENTS

The author would like to express his gratitude to all parties who provided support, assistance, and contributions throughout the research process and the preparation of this article. He also expresses his gratitude to the educational institution where the research was conducted, the participating respondents, and those who provided guidance and input throughout the research. He hopes that the results of this study will benefit the development of science, particularly in technology-based biology learning innovations.

## AUTHOR CONTRIBUTIONS

Conceptualization, R., A.D. and Z.; Methodology, R.; Software, R.; Validation, R., A.D. and Z.; Formal Analysis, R.; Investigation, R.; Resources, A.D.; Data Curation, R.; Writing – Original Draft Preparation, R.; Writing – Review and Editing, A.D. and Z.; Visualization, R.; Supervision, A.D.; Project Administration, Z.; Funding Acquisition, A.D.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

## USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

## REFERENCES

[1] M. A. M. Hashim, I. Tlemsani, and R. Matthews, "Higher education strategy in digital transformation," *Educ. Inf. Technol.*, vol. 27, no. September 2021, pp. 3171–3195, 2022, doi: 10.1007/s10639-021-10739-1.

[2] C. W. Hoerudin, S. Syafruddin, A. Mayasari, O. Arifudin, and S. Lestari, "E-learning as a learning media innovation islamic education," *QALAMUNA J. Pendidikan, Sos. dan Agama*, vol. 15, no. 1, pp. 723–734, 2023, doi: 10.37680/qalamuna.v15i1.4466.

[3] F. Tuma, "The use of educational technology for interactive teaching in lectures," *Ann. Med. Surg.*, vol. 62, no. December 2020, pp. 231–235, 2021, doi: 10.1016/j.amsu.2021.01.051.

[4] G. A. Wibowo, A. A. Karim, S. H. Hasan, and M. Ruhimat, "Use of technology in active learning: Increasing student interaction and engagement," *Al-Hijr J. Adulearn World*, vol. 2, no. 4, pp. 271–293, Nov. 2023, doi: 10.55849/alhijr.v2i4.539.

[5] M. Shahzad, M. A. Nadeem, and Z. U-Nisa, "Developing learning environment using interactive multimedia," *Pakistan J. Distance Online Learn.*, vol. 7, no. I, pp. 93–106, 2021.

[6] B. E. Praheto, Andayani, M. Rohmadi, and N. E. Wardani, "The effectiveness of interactive multimedia in learning Indonesian language skills in higher education," *Rupkatha J. Interdiscip. Stud. Humanit.*, vol. 12, no. 1, pp. 1–11, 2020, doi: 10.21659/rupkatha.v12n1.34.

[7] N. Lagoudakis, F. Vlachos, V. Christidou, D. Vavougios, and M. Batsila, "The use of brain based learning elements in a teaching approach for scientific understanding of biology concepts," *Am. J. Educ. Res.*, vol. 12, no. 7, pp. 247–253, 2024, doi: 10.12691/education-12-7-5.

[8] S. Dargan, M. Kumar, M. R. Ayyagari, and G. Kumar, "A survey of deep learning and its applications: A new paradigm to machine learning," *Arch. Comput. Methods Eng.*, vol. 27, no. 4, pp. 1071–1092, 2020, doi: 10.1007/s11831-019-09344-w.

[9] P. Cholewińska, K. Czyż, P. Nowakowski, and A. Wyrostek, "The microbiome of the digestive system of ruminants – a review," *Anim. Heal. Res. Rev.*, vol. 21, no. 1, pp. 3–14, Jun. 2020, doi: 10.1017/S1466252319000069.

[10] P. R. K. Reddy and I. Hyder, "Ruminant Digestion," in *Textbook of Veterinary Physiology*, Singapore: Springer Nature Singapore, 2023, pp. 353–366. doi: 10.1007/978-981-19-9410-4_14.

[11] L. H. Muhaimin and D. Juandi, "The role of learning media in learning mathematics: A systematic literature review," *J. Math. Math. Educ.*, vol. 13, no. 01, pp. 85–107, 2023, doi: 10.20961/jmme.v13i1.74425.

[12] V. Febrina and D. Setiawan, "Analysis of the use of learning media on the learning interest of learning science students

and environmental themes," *J. Penelit. Pendidik. IPA*, vol. 10, no. 8, pp. 5702–5709, 2024, doi: 10.29303/jppipa.v10i8.7497.
[13] N. Alalwan, "Actual use of social media for engagement to enhance students' learning," *Educ. Inf. Technol.*, vol. 27, no. 7, pp. 9767–9789, 2022, doi: 10.1007/s10639-022-11014-7.
[14] Y. Yulhendri, N. I. Mardhotillah, W. P. Alisha, and N. Susanti, "Analysis of media use and learning interaction to improving student engagement," *Din. Pendidik.*, vol. 17, no. 1, pp. 37–47, 2022, doi: 10.15294/dp.v17i1.35304.
[15] J. Willinsky, "The confounding of race in high school biology textbooks, 2014–2019," *Sci. Educ.*, vol. 29, no. 6, pp. 1459–1476, Dec. 2020, doi: 10.1007/s11191-020-00104-y.
[16] E. Susetyarini and A. Fauzi, "Trend of critical thinking skill researches in biology education journals across Indonesia: From research design to data analysis," *Int. J. Instr.*, vol. 13, no. 1, pp. 535–550, 2020, doi: 10.29333/iji.2020.13135a.
[17] Mirnawati, Takdir, and Irmayanti, "The influence of interactive learning media on students interest in learning in mathematics subjects at UPTD SMPN 7 Sinjai," *JTMT J. Tadris Mat.*, vol. 5, no. 2, pp. 160–165, 2024, doi: 10.47435/jtmt.v5i2.3234.
[18] U. Jannah, A. Qonita, M. N. Ilmi, I. F. Gumita, K. Yustitia, and R. Lefrida, "Designing biology learning media to increase student interest using design thinking method," *J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*, vol. 12, no. 3, pp. 451–461, 2024.
[19] A. P. Putra, G. Roebyanto, and M. Arafik, "Development of interactive web based multimedia for online learning in elementary school," in *Proceedings of the International Conference on Information Technology and Education (ICITE 2021)*, 2023, pp. 62–67. doi: 10.2991/assehr.k.211210.010.
[20] I. K. Suartama *et al.*, "Development of E-learning oriented inquiry learning based on character education in multimedia course," *Eur. J. Educ. Res.*, vol. 9, no. 4, pp. 1591–1603, 2020, doi: 10.12973/EU-JER.9.4.1591.
[21] J. I. Chisunum and C. N. Nwadiokwu, "Enhancing student engagement through practical production and utilization of instructional materials in an educational technology class: A multifaceted approach," *NIU J. Educ. Res.*, vol. 10, no. 2, pp. 81–89, 2024, doi: 10.58709/niujed.v10i2.2002.
[22] D. Djamas, V. Tinedi, and Yohandri, "Development of interactive multimedia learning materials for improving critical thinking skills," *Int. J. Inf. Commun. Technol. Educ.*, vol. 14, no. 4, pp. 66–84, 2018, doi: 10.4018/IJICTE.2018100105.
[23] E. Yuliansih, Y. Arafat, and A. Wahidy, "The influence of learning media and learning interests on student learning outcomes," *JPGI (Jurnal Penelit. Guru Indones.*, vol. 6, no. 2, pp. 411–417, 2021, doi: 10.29210/021064jpgi0005.
[24] B. Bunari, J. Setiawan, M. A. Ma'arif, R. Purnamasari, H. Hadisaputra, and S. Sudirman, "The influence of flipbook learning media, learning interest, and learning motivation on learning outcomes," *J. Educ. Learn.*, vol. 18, no. 2, pp. 313–321, 2024, doi: 10.11591/edulearn.v18i2.21059.
[25] J. Maknun, "Implementation of guided inquiry learning model to improve understanding physics concepts and critical thinking skill of vocational High school students," *Int. Educ. Stud.*, vol. 13, no. 6, pp. 117–130, 2020, doi: 10.5539/ies.v13n6p117.
[26] F. Han, "The relations between teaching strategies, students' engagement in learning, and teachers' self-concept," *Sustain.*, vol. 13, no. 9, pp. 1–15, 2021, doi: 10.3390/su13095020.
[27] F. Asysyura, A. Adnan, and F. Faisal, "The effect of interactive multimedia on students' cognitive learning outcomes on system materials," *Biodidaktika J. Biol. dan Pembelajarannya*, vol. 18, no. 1, pp. 9–23, 2023, doi: 10.30870/biodidaktika.v18i1.17808.
[28] A. Topano, Asiyah, Basinun, A. Walid, Alimi, and D. Febrini, "Improving student cognitive learning outcomes through the development of interactive multimedia-based biology learning at Muhammadiyah University, Bengkulu," in *IOP Conference Series: Earth and Environmental Science*, 2021, pp. 1–10. doi: 10.1088/1742-6596/1796/1/012042.
[29] N. Nurmawati, L. R. Masduki, E. Prayitno, and M. Y. R. Dartani, "The implementation of onteractive multimedia in improving mathematics learning outcomes," *ETERNAL (English Teach. Journal)*, vol. 11, no. 2, pp. 101–107, 2020.
[30] D. A. Yonanda *et al.*, "Improving motivation and learning outcomes of elementary school students with multimedia-based interactive media," *Profesi Pendidik. Dasar*, no. 2021, pp. 197–210, 2024, doi: 10.23917/ppd.v11i3.5761.
[31] M. Ruzafa-Martínez, A. Molina-Rodríguez, V. Pérez-Muñoz, C. Leal-Costa, and A. J. Ramos-Morcillo, "Effectiveness of the flipped classroom methodology on the learning of evidence-based practice of nursing students: Quasi-experimental design," *Nurse Educ. Today*, vol. 128, p. 105878, Sep. 2023, doi: 10.1016/j.nedt.2023.105878.
[32] C. Lam and J. Wolfe, "An introduction to quasi-experimental research for technical and professional communication instructors," *J. Bus. Tech. Commun.*, vol. 37, no. 2, pp. 174–193, Apr. 2023, doi: 10.1177/10506519221143111.
[33] K. Liu, S. Liu, Y. Ma, J. Jiang, Z. Liu, and Y. Wan, "Comparison of blended learning and traditional lecture method on learning outcomes in the evidence-based medicine course: a comparative study," *BMC Med. Educ.*, vol. 24, no. 1, pp. 1–8, 2024, doi: 10.1186/s12909-024-05659-w.
[34] S. Liao and L. Shao, "Graph sampling based deep metric learning for cross-view geo-localization," *J. Phys. Conf. Ser.*, vol. 2711, no. 1, pp. 7359–7368, 2024, doi: 10.1088/1742-6596/2711/1/012004.
[35] E. H. Diken, "Cognitive and metacognitive strategies of 6th-grade students to answer multiple-choice questions on 'human body systems,'" *Int. J. Curric. Instr.*, vol. 12, no. 2, pp. 436–456, 2020.
[36] M. Aslam and F. Smarandache, "Chi-square test for imprecise data in consistency table," *Front. Appl. Math. Stat.*, vol. 9, pp. 01–05, 2023, doi: 10.3389/fams.2023.1279638.
[37] A. E. Kossovsky, "On the mistaken use of the chi-square test in benford's law," *Stats*, vol. 4, no. 2, pp. 419–453, 2021, doi: 10.3390/stats4020027.
[38] U. Basyiroh, A. A. Musadad, M. Muchtarom, and Abu Zarrin bin Selamat, "Systematic review: Android-based interactive learning media to enhance understanding of islamic education in support of SDGs," *Profetika J. Stud. Islam*, vol. 25, no. 02, pp. 533–546, 2024, doi: 10.23917/profetika.v25i02.7877.
[39] E. Zhao, J. He, Z. Jin, and Y. Wang, "Student-centered learning environment based on multimedia big data analysis," *Mob. Inf. Syst.*, vol. 2022, pp. 1–10, Oct. 2022, doi: 10.1155/2022/9572413.

[40] K. H. D. Tang, "Student-centered approach in teaching and learning: What does it really mean?," *Acta Pedagog. Asiana*, vol. 2, no. 2, pp. 72–83, 2023, doi: 10.53623/apga.v2i2.218.

[41] T. D. Nur, U. N. Malang, U. Islam, N. Maulana, and M. Ibrahim, "Learning biology through thinking empowerment by questioning : The effect on conceptual knowledge and critical thinking," *Particip. Educ. Res.*, vol. 10, no. 1, pp. 122–139, 2023.

[42] M. M. Koć-Januchta, K. J. Schönborn, C. Roehrig, V. K. Chaudhri, L. A. E. Tibell, and H. C. Heller, "'Connecting concepts helps put main ideas together': cognitive load and usability in learning biology with an AI-enriched textbook," *Int. J. Educ. Technol. High. Educ.*, vol. 19, no. 1, pp. 1–22, 2022, doi: 10.1186/s41239-021-00317-3.

[43] S. Ubaydullaeva *et al.*, "Modular web-based learning model to address underdeveloped ICT infrastructure for smart e-learning education system," *J. Internet Serv. Inf. Secur.*, vol. 14, no. 4, pp. 450–461, 2024, doi: 10.58346/JISIS.2024.I4.028.

[44] Q. D. Pham, N. N. Dao, T. Nguyen-Thanh, S. Cho, and H. C. Pham, "Detachable web-based learning framework to overcome immature ICT infrastructure toward smart education," *IEEE Access*, vol. 9, pp. 34951–34961, 2021, doi: 10.1109/ACCESS.2021.3062371.

[45] H. Abuhassna and S. Alnawajha, "Instructional design made easy! instructional design models, categories, frameworks, educational context, and recommendations for future work," *Eur. J. Investig. Heal. Psychol. Educ.*, vol. 13, no. 4, pp. 715–735, 2023, doi: 10.3390/ejihpe13040054.