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# Interactive Flipbook E-Module: Based Mammal Practicum to Enhance Biology Education Students' Critical Thinking

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## Abstract

This study aims to develop an interactive flipbook-based e-module as a learning medium for the mammal practicum to enhance the critical thinking skills of biology education students. The research employed a research and development (R&D) approach using the Hannafin and Peck model, which includes three main stages: needs analysis, design and development, and implementation with evaluation. The participants involved were biology education students enrolled in the mammal practicum course. Data were collected through expert validation questionnaires for both content and media, as well as critical thinking tests. The validation results indicated that the developed e-module met the feasibility standards in terms of both content accuracy and visual presentation. Limited trials showed a notable improvement in students' critical thinking abilities after using the e-module. Therefore, the interactive flipbook-based e-module is considered effective and suitable as an alternative learning medium in mammal practicum sessions to support students' critical thinking development.

**Keywords:** *e-module; interactive flipbook; mammal practicum; critical thinking; biology education;*

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## INTRODUCTION

Morphological observations involve identifying external animal structures such as size, shape, color, and body proportions. In taxonomic studies, morphological characteristics serve as the primary criteria for recognizing and distinguishing species (Rohlf & Marcus, 2021). These observations form the basis of biological classification systems that support accurate description and identification of specimens. External morphology of mammals such as ear shape, tail, limbs, and hair distribution is crucial in the initial classification process (Kitchener et al., 2020).

Morphometrics is a quantitative technique used to measure the shape and size of body organs, either linearly or geometrically. This approach aims to reveal variations in shape that are not readily apparent through visual observation alone (Zelditch et al., 2012). In vertebrate zoology, this technique is employed to compare specimens based on standard parameters such as skull length, tail diameter, or ear width (Cardini & Polly, 2020). Morphometric data provide in-depth information that supports evolutionary analysis, speciation studies, and geographical variation in mammals.

Meristic characteristics refer to the number of repeated body structures, such as the number of vertebrae, digits, or teeth. Meristic data are important in identification because they are generally consistent within the same species (Galis et al., 2018). In mammals, meristic data are often used to differentiate species that appear morphologically similar. For example, the number and arrangement of teeth can serve as diagnostic indicators in the classification of orders or families (Wilson & Mittermeier, 2011).

Mammal identification requires an integrative approach that combines morphological, morphometric, and meristic data, along with molecular analysis when necessary. This technique aims to determine the taxon of the observed individual, either at the species or subspecies level (Burgin et al., 2018). The use of dichotomous keys, morphological atlases, and digital data greatly facilitates the identification process, especially in higher education. This process supports critical thinking and classification skills in zoological studies (Kingdon, 2020).

Biology education at the higher education level demands mastery of intellectual skills that go beyond theoretical knowledge, including critical thinking, observation, and analysis in scientific practice. One of the key competencies that must be developed is students' critical thinking ability through practicum-based learning, particularly in vertebrate zoology courses that explore animal diversity based on morphological, morphometric, and meristic characteristics (Zubaidah, 2019; Ennis, 2015).

Critical thinking is an essential skill that university students must possess, especially in facing the challenges of an ever-evolving era of science and technology. According to Ennis (1996), critical thinking is a reflective and rational thinking process used to decide what to believe or do. This requires students to be able to evaluate information objectively, consider multiple perspectives, and make decisions based on logical reasoning and valid evidence. Dewey (2019) also emphasized that critical thinking arises from the habit of actively and continuously questioning the basis of beliefs or assumptions, so that students do not easily accept information without careful consideration.

In the context of biology learning, particularly in mammal practicums, students' critical thinking skills are highly necessary to help them understand concepts deeply, connect theory with empirical facts, and draw conclusions based on collected data. Practicum activities such as morphometric identification (measuring mammalian body dimensions) and meristic identification (counting specific body traits) require students to carefully analyze data, compare findings with literature, and logically interpret their observations. Norris and Ennis (1989) emphasized that critical thinking must be assessed systematically through tasks that challenge students' analytical and reflective abilities.

The mammal practicum, as part of vertebrate zoology, serves as a primary medium for students to apply taxonomic knowledge in real-life contexts. Mammals are chosen because of their complex and diverse characteristics, such as body structures, dental patterns, and broad physiological adaptations (Vaughan et al., 2015). Unfortunately, conventional practicum activities still face several challenges, such as limited specimens, monotonous learning media, and the suboptimal use of technology to support students' learning experiences (Akmalia & Mulyani, 2020; Hasanah et al., 2022).

With the advancement of the digital era, the use of interactive learning media has become an urgent need in designing 21st-century skills-based learning. One promising innovation is the development of interactive flipbook-based e-modules, which not only present visually engaging materials but also allow the integration of interactive elements such as videos, animations, quizzes, and digital practicum guides (Wijaya et al., 2022; Fatimah & Widodo, 2023). This type of digital module has been proven to enhance conceptual understanding, active engagement, and students' critical thinking skills (Prastowo et al., 2021; Cilliers, 2017).

The use of morphological, morphometric, and meristic approaches in the process of mammal species identification can serve as a means to train students in objectively analyzing differences between taxa, formulating scientific arguments, and drawing conclusions based on observational data (Zelditch et al., 2012; Cardini & Polly, 2020). This process directly contributes

to the improvement of critical thinking skills, which is one of the key indicators in biology education curricula based on scientific competencies (Facione, 2011; Krajcik & Czerniak, 2018). Therefore, the development of an interactive flipbook-based e-module for mammal practicums that integrates aspects of morphology, morphometrics, meristics, and taxonomic identification not only aims to enrich learning media, but also serves as an innovative strategy to systematically and measurably enhance the critical thinking abilities of biology education students.

## METHODS

This study employed a Research and Development (R&D) approach, focusing on the design and development of an interactive flipbook-based e-module for mammal practicum. The primary goal of this development was to produce a learning medium that is both valid and effective in enhancing biology students' critical thinking skills. The research adopted the Hannafin and Peck model, which consists of three main phases: (1) needs analysis, (2) design, and (3) development and implementation (Hannafin & Peck, 1987). This model was chosen because it facilitates a systematic process for designing technology-based learning media tailored to the characteristics of students and the needs of practicum activities.

The study was conducted with students from the Biology Education Study Program at Universitas Negeri Jakarta. Participants were selected using purposive sampling, targeting individuals deemed appropriate for the study's objectives—namely, students who had taken the Vertebrate Zoology course. The limited trial involved 10–15 students, while the field trial involved 36 students. Additionally, the study engaged subject matter experts, instructional media experts, and zoological practicum experts as validators for the e-module development.

The data collection techniques involved three main methods. First, the document review method was used to collect and describe the results of the needs analysis, the design of the interactive flipbook-based e-module for the mammal practicum, and other supporting documents during the needs assessment and planning to design stages of the Hannafin and Peck development model. Second, the questionnaire method was employed to collect validation and review data from subject matter experts and media experts (Arikunto, 2014). Third, the test method was used to measure the improvement of students' critical thinking skills through case-based questions related to morphometric and meristic data (Arikunto, 2014).

The data from the validation of the interactive flipbook-based e-module for the mammal practicum were analyzed quantitatively to determine the feasibility level of the media. The analysis was conducted by calculating the percentage scores, which were then interpreted based on media feasibility criteria (Akbar, 2013).

Students' cognitive data were obtained from test scores administered before (pretest) and after (posttest) the use of the interactive flipbook-based e-module in the mammal practicum. To measure the improvement in students' critical thinking skills after using the e-module, a Normalized Gain (N-Gain) calculation was performed. The N-Gain calculation was used to assess the effectiveness of the e-module in enhancing students' cognitive learning outcomes. The resulting N-Gain scores were then interpreted using established criteria (Hake, 1998). The data from this analysis were used to evaluate both the improvement in students' critical thinking skills and the effectiveness of the interactive flipbook-based e-module in the Mammal class of the Vertebrate Zoology practicum.

## FINDING AND DISCUSSIONS

### Student Needs Analysis

The needs analysis was conducted to ensure that the development of the interactive flipbook e-module effectively addresses real problems encountered in the Vertebrate Zoology practicum. The interactive flipbook e-module developed in this study is a digital learning medium in the form of an electronic module, equipped with features such as page-flipping simulation (flip effect), images, videos, quizzes, and practice questions, designed to facilitate independent,

contextual, and active learning for students. This media is expected to support students' critical thinking processes through the presentation of content that is visual, dynamic, and responsive to learning needs.

The results of the questionnaire indicated that students have a high demand for interactive learning media and that there are several challenges in conventional learning approaches. A summary of the needs analysis results is presented in the following table:

Table 1. Results of Needs Analysis for the Interactive Flipbook E-Module.

| No | Aspect of Needs Analysis | Indicator | Average Score | Category |
|---|---|---|---|---|
| 1 | Need for interactive learning media | Need for e-modules with visual and interactive media | 3,56 | High |
| | | Expectation for access to engaging and easy to understand materials | 3,56 | High |
| | | Perception that interactive media is essential in practicum activities | 3,56 | High |
| 2 | Problems in conventional learning | Difficulty in understanding material independently | 2,41 | Enough |
| | | Textbooks have not become the primary learning resource | 2,33 | Enough |
| | | Teaching methods used by lecturers are less effective or inappropriate | 2,22 | Enough |
| | | Low interest due to non-contextual presentation of material | 2,22 | Enough |
| | | Lack of visual media in the learning process | 2,19 | Enough |
| 3 | Potential of interactive flipbook e-modules to enhance critical thinking | Students' positive perception of interactive e-modules | 2,98 | High |

The results in Table 1 show that students view the interactive flipbook e-module as an essential need to support Vertebrate Zoology practicum. Research by Iwan et al. (2023) reinforces this through a flipbook-based e-module on protist material, which effectively improved biology learning outcomes due to its interactive design that fosters active student engagement. Similarly, Ainy et al. (2023) stated that digital flipbook e-modules can enhance middle school students' problem-solving skills in science learning through systematic, engaging content presentation that supports independent learning. In addition, Ayuardini (2022) also emphasized that interactive flipbook e-modules make it easier for students to understand biological concepts due to their appealing visuals and user-friendly navigation. The problems found in conventional learning as revealed in this study further reinforce the urgency of developing digital media to support contextual learning and foster students' critical thinking skills.

**Lecturer Needs Analysis**

The questionnaire distributed to lecturers revealed that the development of an interactive flipbook e-module is highly necessary as a solution to the various challenges faced in mammal identification practicums. Lecturers emphasized that visualization of morphometric and meristic characteristics, integration of critical thinking exercises, and contextual presentation of material

are key needs that have not yet been fulfilled by conventional practicum media. Furthermore, the current learning media are considered suboptimal in supporting the development of students' higher-order thinking skills. Therefore, innovation in the form of an interactive digital e-module is needed to facilitate students in learning actively, independently, and in a structured manner. These findings are consistent with the views of Iwan et al. (2023), Ainy et al. (2023), and Ayuardini (2022), who stated that interactive flipbook e-modules are effective as learning media because they support material visualization, enhance problem-solving skills, and improve biology learning outcomes through engaging, systematic content and the encouragement of self-directed learning.

**Expert Validation Analysis**

The media validation test was conducted on seven aspects: module size, module cover layout, cover typography, cover illustration, content layout, content typography, and content illustration. Based on data analysis, all aspects achieved a feasibility percentage in the range of 81–100%, thus categorized as "highly feasible" (Akbar, 2013). This indicates that the developed interactive flipbook e-module meets the media feasibility standards in terms of visual design, layout, typography, and illustrations, which support readability and user comfort.

The media and content validation results, which fall into the "highly feasible" category, indicate that the developed interactive flipbook e-module meets good quality standards for use as a practicum learning medium. This is in line with the research by Renaldy et al. (2025), which asserts that systematically validated instructional media—especially in terms of visual design, interactivity, and content integration—play a crucial role in supporting the effectiveness of practicum-based learning. Media validation not only ensures display quality and functionality but also guarantees that the media can facilitate students in understanding concepts, developing critical thinking skills, and connecting theory with practice.

The material validation was conducted on five aspects: content accuracy, completeness and coherence, readability and language accuracy, clarity of instructions and presentation format, as well as visual appeal and interactivity. All aspects were also rated as "highly feasible," with feasibility percentages exceeding 81% for each aspect (Akbar, 2013). This indicates that the material in the e-module aligns with the scientific standards of vertebrate zoology, is complete and well-structured, uses appropriate language, and includes interactive elements that support learning outcomes.

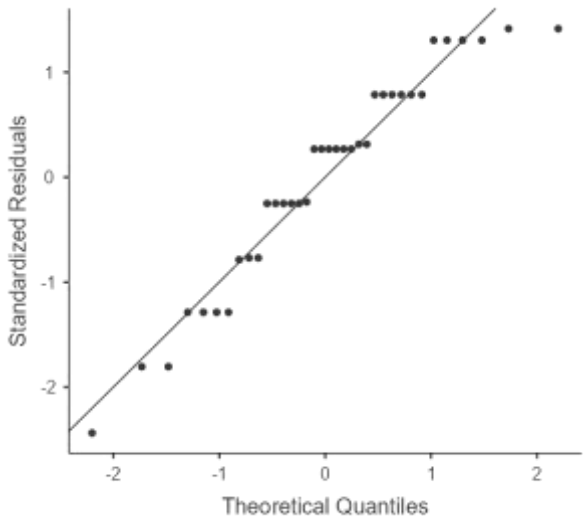
The "highly feasible" rating on the content aspect confirms that the e-module's content is well-suited to the needs of the Mammalia class in Vertebrate Zoology practicum. The material presents morphometric and meristic concepts in a factual, systematic, and relevant manner. These findings are in line with the research of Meldrawati et al. (2023), which demonstrated that problem-based learning e-modules with systematic, contextual, and learner-centered content presentation are considered highly valid for use in biology education. Such material validation is essential to ensure that the e-module is not only scientifically accurate but also effective in supporting students' critical thinking skills.

After completing the needs analysis and validating the media and content, the next step in this study was to implement the interactive flipbook e-module in the mammal practicum and measure its effectiveness in enhancing students' critical thinking skills. This measurement was conducted through the administration of critical thinking tests before (pre-test) and after (post-test) the use of the e-module. To ensure the validity of the results, a series of statistical tests were conducted on the collected data, including tests for normality, homogeneity, validity and reliability of the instrument, as well as inferential analysis using ANOVA and Normalized Gain (N-Gain) calculation. The results of these analyses served as the basis for determining the extent to which the use of the e-module impacted the improvement of biology education students' critical thinking skills in the Vertebrate Zoology practicum focusing on mammals.

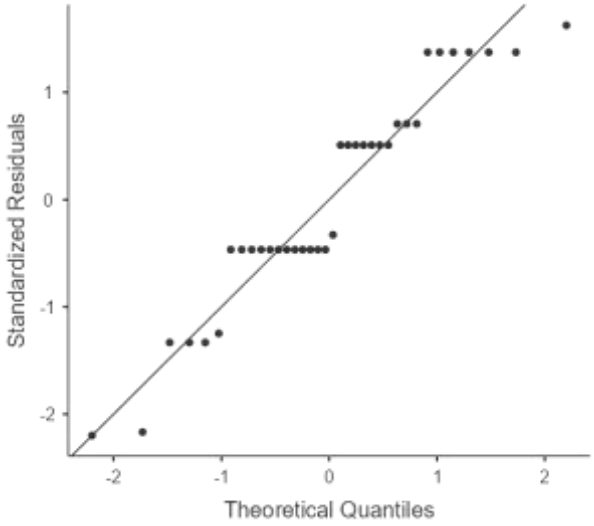
The post-test scores showed relatively homogeneous results with a tendency toward high scores. This indicates that students were able to understand the material thoroughly through the interactive and visual approach presented by the flipbook e-module. Students also appeared to be

more active and engaged in the learning process, particularly during data analysis and discussion sessions that required critical thinking.

**Statistical Test Results**




Grafik 1. < Quantile-Quantile Plot (Pre-test)>




Grafik 2. < Q-Q Plot (Post-test)>

Based on the results of the two Q-Q Plot graphs analyzed, it can be concluded that the residual distribution of the research data tends to follow a normal distribution. The data points in both graphs mostly align along the theoretical quantile line, indicating that the assumption of normality is met. Although there are slight deviations at the upper and lower tails, these remain within acceptable limits and do not affect the validity of the parametric analysis used in this study.

The fulfillment of the normality assumption supports the reliability and validity of the statistical model used to analyze the effect of developing an interactive flipbook-based e-module in the mammal practicum on the critical thinking skills of biology education students. Therefore, further analyses such as ANOVA or pre-post score gain tests can be interpreted scientifically, as the data meet the required distribution assumptions.

**1. Normality Test**

The normality test was conducted to determine whether the post-test score data followed a normal distribution. Based on the Shapiro-Wilk test, the obtained significance value (p-value) was greater than 0.05, indicating that the data are normally distributed and suitable for further parametric analysis.

**2. Homogeneity Test**

Next, a homogeneity test was conducted to determine whether the data had uniform variance. Levene's test showed a significance value greater than 0.05, indicating that the data are homogeneous.

**3. Validity Test**

The critical thinking test instrument was validated using Pearson correlation between each item score and the total score. The analysis results showed that most items had correlation coefficients above the critical r-table value, indicating that the instrument is valid and appropriate for use.

**4. Reliability Test**

The reliability of the instrument was tested using the Cronbach's Alpha formula. The calculation results showed an α value greater than 0.70, indicating that the instrument is reliable and has good internal consistency.

**5. ANOVA Test**

To determine significant differences in students' learning outcomes, an ANOVA test was conducted on the post-test scores. The results showed that the calculated F-value was greater than the F-table value, with a significance level of less than 0.05. This indicates that there were significant differences and that the e-module had a substantial effect on improving critical thinking skills.

Based on the results of statistical testing and direct field observations, the development of the interactive flipbook e-module in the mammal practicum proved to be effective in enhancing students' critical thinking abilities. This learning medium was deemed valid, reliable, and suitable for use in inquiry-based practicum learning.

Table 2. Results of ANOVA Test (Pre-Test)

| | Sum of Squares | df | Mean Square | F | p | $\eta^2p$ |
|---|---|---|---|---|---|---|
| **Overall model** | 5.04 | 1 | 5.04 | 1.31 | 0.260 | |
| **Jenis Kelamin** | 5.04 | 1 | 5.04 | 1.31 | 0.260 | 0.037 |
| **Residuals** | 130.96 | 34 | 3.85 | | | |

Table 3. Results of ANOVA Test (Post-Test)

| | Sum of Squares | df | Mean Square | F | p | $\eta^2p$ |
|---|---|---|---|---|---|---|
| **Overall model** | 11.9 | 1 | 11.9 | 0.135 | 0.716 | |
| **Jenis Kelamin** | 11.9 | 1 | 11.9 | 0.135 | 0.716 | 0.004 |
| **Residuals** | 3005.1 | 34 | 88.4 | | | |

## CONCLUSION

The development of an interactive flipbook-based e-module for the mammal practicum has proven to be an innovative and effective solution for enhancing the critical thinking skills of biology education students. This e-module successfully integrates morphological, morphometric, and meristic approaches into an interactive, visual, and contextual digital learning medium. Expert validation results indicated that the module is highly feasible in terms of both content quality and visual design. In addition, the needs analysis from both students and lecturers reinforces the urgency of developing this media as a response to the limitations of conventional practicum methods.

The effectiveness test results showed a significant improvement in students' critical thinking abilities following the use of the e-module, as indicated by high and consistent post-test scores. This interactive flipbook e-module not only supports the scientific identification of mammal specimens, but also promotes active engagement, independent learning, and the development of higher-order thinking skills. Therefore, this media is suitable for widespread

implementation in vertebrate zoology education and can serve as a model for the development of technology-based practicum materials in the digital era.

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