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Development of Preserved Invertebrate Specimens for Enhancing Biology Laboratory Learning at Timor University

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Abstract: *Laboratories play an important role in biology learning, especially in specimen observation-based practicums. However, the Biology Education Laboratory at Timor University does not yet have preserved invertebrate specimens as supporting media, necessitating the development of alternative learning media. This study aims to develop preserved invertebrates to improve the quality of invertebrate zoology practicums. The development was carried out using the ADDIE model, including analysis through needs surveys, media design with sampling and design preparation, development through expert validation and revision processes, implementation in practicums through pretests, posttests, and student response questionnaires, and summative evaluation to assess the effectiveness of the media. The evaluation results showed an increase in student understanding after using preserved invertebrate media, so this development was considered effective in supporting practicum activities and improving the quality of biology learning at Timor University. The result development of preservation media for invertebrate animals has been successfully carried out through validity test by material expert tests (84%), media expert tests (80%). Preservation media for invertebrate animals has a high practicality value (82%) & high effectiveness (80%). The different pretest rate (65) and posttest rate (84,5) results are quite significant and have a correlation due to the presence of preservation media for invertebrate animals.*

Keywords: *Development, Preserved Invertebrates, ADDIE, Biology Laboratory Learning, Practically Value, Effectiveness*.

1. INTRODUCTION

Biology laboratories play a crucial role in supporting learning, particularly in the practice of direct observation of biological specimens (Amalia et al., 2024). Likewise, the availability of laboratory facilities should be prioritized to ensure the smooth running of the learning process, particularly biology labs (Kamaluddin & Hano'e, 2022). One essential component of laboratory facilities in biology learning is the use of preserved specimens, both wet and dry (Artayasa et al., 2020). These preserved specimens serve as laboratory materials, enabling students to gain a deeper understanding of the structure and morphology of organisms (Ananta et al., 2018). They also serve as an alternative to laboratory materials that utilize live, natural animals sustainably sourced for use in laboratory activities (Sitompul & Siregar, 2020).

Invertebrates are a highly diverse group of organisms and are frequently studied in biology. However, the availability of well-preserved invertebrate specimens often presents a barrier to learning (Lestari, 2020). This is due to limited facilities, a lack of representative specimen collections, and suboptimal preservation methods (Fikriyya & Sulistyawati, 2019). As a result, students experience difficulties in identifying and

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analyzing the morphological and anatomical characteristics of invertebrates.

As a higher education institution focused on the development of science, including biology, Timor University needs to improve the quality of learning by providing adequate laboratory facilities. One possible approach is to develop a method for preserving invertebrate specimens in the form of preservatives. Proper preservation will ensure the specimens remain intact for a long time, allowing them to be used sustainably in practical activities (Macri & Di-Poi, 2024).

With the development of preserved invertebrates as a supporting facility for practical work at the Biology Laboratory at Timor University, it is hoped that the quality of biology learning will improve. Students will gain a better learning experience, particularly in understanding the biodiversity, body structure, and physiological functions of invertebrates. Furthermore, this innovation can also support research and biodiversity conservation activities in the surrounding area (Vaughn and Jackson, 2022).

Research into the development of preserved invertebrates has indeed been extensively conducted. However, the availability of preserved invertebrates for the continuity of good learning is urgent and must be carried out immediately. This research can be a solution to improve the quality of learning by providing adequate laboratory facilities (Ananta et al., 2018). The state-of-the-art and novelty of this research is that the availability of preserved invertebrates for the continuity of biology practical learning can improve student learning outcomes and interest, as well as enhance the quality of learning at Timor University. Furthermore, the results of this research indirectly improve the University's budget efficiency (Artayasa et al., 2020) in providing facilities and infrastructure for practical work in the laboratory, allowing the budget to be used for other, more important needs.

Regarding the five-year research roadmap, researchers are focusing on developing teaching materials in their field of study, namely zoology. This decision is expected to help meet the needs of learning facilities at Timor University, thereby assisting educators in achieving learning objectives and improving the quality of learning.

2. RESEARCH METHOD

This research was conducted through several sequential stages: (1) research design; (2) population and samples; (3) sample collection techniques and instrumental development; and (4) data analysis techniques. This research employed a Research and Development (R&D) design based on the ADDIE instructional development model, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation (Loukili et al., 2025; Dewi & Carolina., 2024; Fahriza et al., 2023).

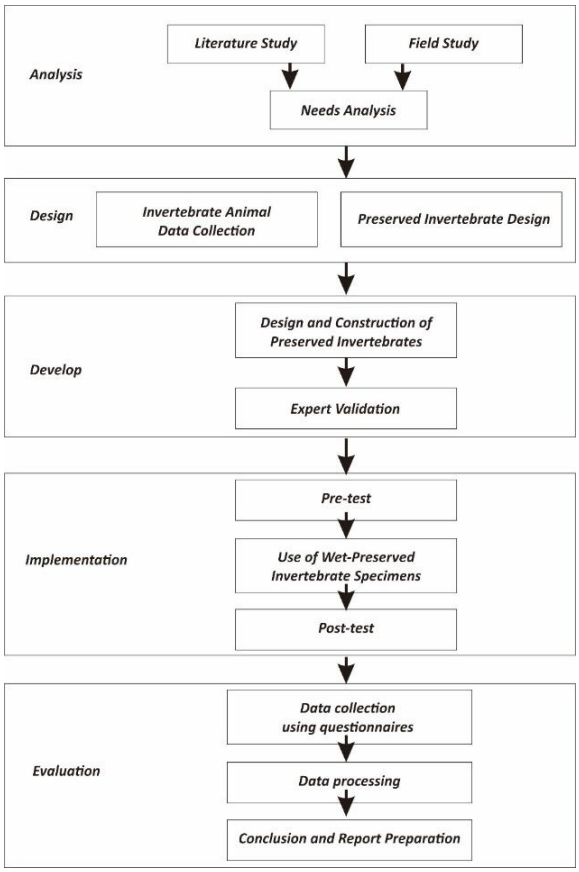


Figure 1. Research Design

The development procedure for preserved invertebrate learning media aimed at improving learning quality was conducted through the following stages: 1) *Analysis*: This stage involved a field survey to identify problems in invertebrate zoology learning, an analysis of student needs related to the availability of instructional materials, and an analysis of graduate learning outcomes and course learning outcomes. 2) *Design*: This stage included collecting

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invertebrate samples from Teluk Gurita Beach, preparing the tools and materials required for producing preserved invertebrate media, designing the learning media, and developing the media based on the results of the field analysis conducted at the Biology Education Laboratory, University of Timor. 3) *Development*: This stage consisted of validating the preserved invertebrate media through expert judgment involving media experts, subject-matter experts, and lecturers of the relevant courses, followed by revisions based on the validation results (Dewi & Carolina., 2024). 4) *Implementation*: This stage involved applying the developed media in invertebrate zoology practicum activities, administering pretests and posttests, and distributing student response questionnaires to evaluate the use of preserved invertebrate media during practicum sessions (Amalia et al., 2024). 5) *Evaluation*: This stage comprised a summative evaluation conducted through tests administered before and after the practicum activities to compare student learning outcomes prior to and following the use of preserved invertebrate media. The results were used to determine the effectiveness of the media in the learning process and to conduct final revisions in order to produce an optimal product (Lolowang et al., 2023).

This research was conducted July-October 2025 in Tanjung Bastian Beach and Teluk Gurita Beach (Marine invertebrate sampling) and in Biology Education Laboratory of Timor University (Create and test preserved invertebrate media). The research tools used in this study include: surgical instruments, jars, masks, tweezers, graduated cylinders, and gloves. The materials used in this study include: 37% Formaldehyde Solution, Glacial Acetic Acid Solution, 70% Alcohol Solution, and Aquadest Solution (Rahayoe et al., 2019). FAA solution is created by a ratio of 37% formaldehyde solution: glacial acetic acid solution: 70% alcohol solution (5 ml: 5 ml: 90 ml).

Marine invertebrate sampling was conducted at Tanjung Bastian Beach and Teluk Gurita Beach, Belu Regency, and terrestrial invertebrate sampling was conducted around the University of Timor. The invertebrate preservation and media implementation will be conducted at the Biology Education Laboratory, University of Timor. The research subjects will be biology education students majoring in invertebrate zoology.

Invertebrate Preservation steps: *1) Kill the specimen.* The euthanasia process is carried out quickly and ethically by boiling the specimen. If the specimen is dead, proceed to fixation. *2) Initial fixation with FAA.* Place the specimen immediately in a container filled with fresh FAA. The liquid-to-specimen ratio should be at least 10:1 (by volume) to ensure penetration and prevent decay. For large invertebrates (e.g., large mollusks, large crustaceans), make a small incision or inject the FAA solution into the body cavity to allow the fixative to penetrate the deep tissues. Use a needle/pipette. Fixation time: varies — from 12–48 hours to several days depending on the size and density of the tissue. For small soft tissues, 24–48 hours is often sufficient. Do not leave the specimen in formalin for too long if you plan to preserve its natural color — formalin reduces the color's brightness over time. *3) Washing/Solution Change*. After initial fixation (e.g., 24–48 hours), discard the initial FAA and rinse/transfer the specimen through several water changes or directly to 70% ethanol (or 70–75% EtOH) for long-term storage. Many museums recommend transferring to 70–75% ethanol for long-term storage, as formalin poses long-term problems and can potentially damage labels. *4) Long-term Storage.* Store in 70–75% ethanol (minimum 10:1 by volume). Close the container tightly and label thoroughly (specimen name, collection location, date, collector, preliminary identification). For some invertebrates (e.g., small insects), alcohol greater than 70% tends to make fragments more fragile—adjust accordingly for the taxon (Ceriaco & Marques, 2025).

The population of this study is biology education students taking invertebrate zoology courses. A sample of 30% of the population will be drawn using random sampling (Cahaya et al., 2024). The study will be validated by lecturers specializing in media and animal systematics.

Data for this study were collected through the following instruments (Musfirah et al., 2025): 1) *Invertebrate Preserve Validation Instrument (Non-Test):* The validation sheet was conducted by media experts and material experts on invertebrate zoology. Media aspects assessed included: ease of use, durability, practicality, readability, and clarity of instructions for use.

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Material aspects assessed included: suitability of species data to the preserve, appropriateness of writing, readability, and depth of information (Fitria et al., 2025). 2) *Invertebrate Preserve Practicality Instrument (Non-Test)*: A student response questionnaire to assess ease of use and understandability of the preserve media (Usman et al., 2025). 3) *Invertebrate Preserve Effectiveness Instrument (Test)*: A test of understanding of invertebrate zoology concepts before and after use of the preserve media. This test was measured using pre-test and post-test questions. The pre-test consisted of 10 questions related to the characteristics, types, and classification of invertebrates. The post-test instrument consists of 20 questions related to the characteristics, types, and classification of invertebrates (Ryanto et al., 2025). The instrument will be validated by one lecturer specializing in learning evaluation. 4) *Documentation*: Documentation is useful for gathering additional data to deepen the research results obtained through the practicum process, including pre-test scores before the practicum, response scores after the practicum, and documentation of research files or special notes supporting the research activities (Mahmudi et al, 2025).

Data analysis techniques consist of analysis of validator assessment results data (*media validity test*), analysis of invertebrate animal preservation practicality (*media practicality test*), analysis of invertebrate animal preservation effectiveness (*media effectiveness test*) (Susiani et al., 2024), & analysis of student learning outcomes (Pangsuma et al., 2024).

1) *Validator Assessment Data Analysis (Media Validity Test)*: Data analysis of the invertebrate preservation media validation results was conducted using qualitative descriptive analysis. The data summary process was entered into a microsoft excel table. The validation results from all validators were calculated using the following formula (Susiani et al., 2024; Suci & Sunismi, 2024).

$$P = \frac{\sum X}{\sum Xi} X\ 100\%$$

Note:
P = percentage of scores obtained
∑X = total scores obtained for each statement
∑Xi = highest total score

The results of the media validity calculation can be interpreted using a Likert scale with the following categories and percentages. The quality of the preservation media in this study is considered valid and ready for use if it falls into the good or very good category (Susiani et al., 2024; Hardila and Vebrianto, 2024).

2) *Analysis of Practicality of Invertebrate Preservation (Media Practicality Test)*: Preservation media that have been validated by experts are then used in limited trials to test the practicality of the developed invertebrate preservation media. The results of the questionnaire score recap were then calculated using the following formula:

$$Score = \frac{total\ respondent\ score}{number\ of\ questions\ x\ number\ of\ respondents}$$

For further purposes, the analysis will be categorized as shown in Table 3.1. The quality of the preservation media in this study is considered practical and ready for use if it falls into the good or very good category (Sitompul & Siregar, 2020; Atmazak et al., 2023).

3) *Analysis of Invertebrate Preservation Effectiveness (Media Effectiveness Test)* (Sinaga et al., 2023): The effectiveness of the preservation media is measured based on the increase in understanding of Invertebrate Zoology concepts using the N-gain score with the formula:

$$Score = \frac{total\ respondent\ score}{number\ of\ questions\ x\ number\ of\ respondents}$$

Table 1. Likert Scale Categories for Validity, Practically, and Effectiveness (Saydah et al., 2024)

No	Interval	Category
1	$0\% \leq Value \leq 20\%$	Very poor
2	$20\% < Value \leq 40\%$	Poor
3	$40\% < Value \leq 60\%$	Fairly good
4	$60\% < Value \leq 80\%$	Good
5	$80\% < Value \leq 100\%$	Very good

Table 2. N-Gain Criteria (Woa et al., 2022)

No	Interval	Category
1	$Value \geq 0{,}70$	High
2	$Value < 0{,}70$	Moderate
3	$Value < 0{,}30$	Low

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4) Analysis of Student Learning Outcomes (Wahid, 2025)

- *Normality Test:* The normality test ensures that the data follows a normal distribution, a key assumption for many statistical procedures such as the t-test and ANOVA (Apriatmo et al., 2021). The homogeneity test of variance confirms that the variances of the different groups are similar, another important assumption for certain tests. The normality test aims to ensure that the data are normally distributed, a prerequisite for many parametric statistical tests. The data normality test was performed using the Kolmogorov-Smirnov test using SPSS. The data are considered normally distributed if the sig. value of the Kolmogorov-Smirnov test is greater than the 5% significance level (0.05) (Laksana, 2024)
- *Homogeneity Test*: The homogeneity test ensures that the variances of the different groups are similar. The data homogeneity test was performed using the Levene statistic using SPSS. The data are considered homogeneous if the p-value of the test is greater than the significance level (usually 0.05) (Govindasamy et al., 2023).
- *Mean Student Learning Outcome Mastery Test*: The average student learning outcome mastery test was based on the minimum passing grade used at the research site, which was 70. The test was conducted using the following hypotheses:

  H0: $\mu \leq 70$: The average student learning outcome using preserved media is less than or equal to 70, therefore the hypothesis is accepted.

  H1: $\mu > 70$: The average student learning outcome using preserved media is greater than 70, therefore the hypothesis is rejected.

  To calculate the completeness of student learning outcomes, the following formula is used:

$$t = \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}}$$

  Note:
  t = calculated t-value
  $\bar{x}$ = mean value
  μ_0= hypothesized value
  s = sample standard deviation
  n = number of sample members

  Where, t_table is obtained from the t-distribution list with a 5% error rate and dk = (n-1). H_0 is accepted if t_table ≤ t_calculated, meaning student learning outcomes are not greater than or equal to the assumed population mean of 70. Otherwise, H_1 is accepted (McAleer et al., 2021).
- *Paired Sample t-test*: The data analysis technique used by researchers to determine the effect of preserved media on learning outcomes measured using two variables (pre-test and post-test) is a paired-sample t-test or one-group pretest-posttest design. This design involves one group being measured at baseline (O1), then given a treatment (X), and then measured again after the treatment (O2). This study aims to observe changes in one group after the treatment, but there is no control group to compare the results. In this study, the pre-test was conducted before the use of the preservation media, while the post-test was conducted after the use of the preservation media. The following is a schematic of the paired sample t-test design:

Pre-test	Treatment	Post-test
O_1	X	O_2

Figure 2. Treatment Scheme

This test calculates the difference between the values of two variables for each case and tests whether the mean difference is zero. The data criteria for the paired sample t-test are that the data for each pair tested are on an interval or ratio scale and that the data are normally distributed. The statistical calculations for the test were performed using SPSS with the following hypotheses:

H_0: $\mu_1-\mu_1=0$: There is no difference between the old and new methods in student ability on a given topic.

H_1: $\mu_1- \mu_2\neq0$ :: There is a difference between the old and new methods in student ability on a given topic.

The measurement results show that H_0 is accepted if the sig value is > 5% (0.05) and

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H_0 is rejected if the sig value is < 5% (0.05) (Talikan et al., 2024).

3. RESULTS AND DISCUSSION

This study aims to examine the development of preserved invertebrate media and its suitability as a supporting medium for practical work in the Biology Education study program at Timor University. It also examines the effectiveness of using preserved invertebrate media as a supporting facility for practical work in the Biology Education study program at Timor University, thereby improving the quality of learning. This study used the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) Research and Development Model design to achieve the research objectives.

ADDIE Development Results: The ADDIE Development Results consist of the analysis, design, development, evaluation, and implementation stages.

1) *Analysis Stage:* The analysis stage is the initial stage in the ADDIE model development research, which aims to identify student needs, characteristics, core competencies, and external factors in an effort to improve the quality of learning (Aman et al., 2025; Suryani et al., 2024). The research results indicate that the primary problems and needs of biology students at Timor University, particularly those studying invertebrate zoology, include: 1) a lack of laboratory facilities and media for demonstrating the morphological structures of invertebrates and vertebrates. Currently, laboratory activities involve hunting directly in the field or around Timor University to obtain invertebrate samples for direct identification of morphological structures. 2) The current practice of hunting indirectly exploits animals annually. This can be addressed by creating preservation media for invertebrates. 3) The current practice only obtains samples of certain invertebrates, including members of the arthropod phylum, such as insects found around us. Marine invertebrate samples cannot be directly obtained due to the distance from the university and the higher cost involved.
2) *Design Stage:* The design stage is a follow-up stage following the initial stage. It aims to design and create the structure, content, and form of a wet preservation medium for invertebrates, which provides solutions to the needs analysis (Stepnicka et al., 2025). This stage involves two stages of development. First, marine invertebrate samples were collected from Tanjung Bastian Beach and Teluk Gurita Beach, as well as from the campus area. Marine invertebrate samples were collected from Tanjung Bastian Beach and Teluk Gurita Beach on July 19, 2025, and from the campus area on July 26, 2025. Second, wet preservation of these invertebrates was prepared before sampling and concurrently with field sampling. Preservations were made by mixing 5 ml of 37% formaldehyde solution, 5 ml of glacial acetic acid solution, and 90 ml of 70% alcohol solution in a 5:5:90 ratio (Nachman et al., 2023; Ceriaco & Marques, 2025; Vaughn & Jackson, 2022). This solution was prepared on July 17-18, 2025, before being transported to the beach for preservation.

The sampling results indicate that a total of 15 invertebrate species comprising 32 individuals were successfully inventoried from two coastal locations—Tanjung Bastian (TB) and Teluk Gurita (TG)—as well as from terrestrial areas around the Timor University campus (KUT) (Table 3). This distribution reflects the ecological heterogeneity of the sampling sites, where marine, intertidal, and terrestrial habitats contribute to differences in invertebrate diversity and abundance. (Table 3). The dominance of the phylum Echinodermata in coastal waters (e.g., *Asterias* sp., *Ophiotriix* sp., *Tripneustes gratilla*, *Echinus* sp., and *Holothuria* sp.) is consistent with their ecological preference for benthic marine environments, particularly coral reef and seagrass ecosystems. Echinoderms are widely recognized as bioindicators of marine ecosystem health due to their sensitivity to environmental changes (Lang et al., 2023; Delgado et al., 2024). Their presence across both Tanjung Bastian and Teluk Gurita suggests relatively suitable substrate and water quality conditions. The phylum Mollusca showed the highest species representation, including *Achatina fulica, Tegillarca granosa, Perna viridis, Hinia reticulata*, and *Loligo* sp. This aligns with previous findings that mollusks possess high adaptability across

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marine and terrestrial ecosystems, owing to their varied feeding strategies and habitat tolerance (Darrigran et al., 2025). The occurrence of Hinia reticulata and Echinus sp. in both TB and TG indicates overlapping ecological niches and similar coastal characteristics between the two sites. Terrestrial sampling at the university campus yielded representatives of Annelida (*Lumbricus terrestris, Hirudo medicinalis*) and Arthropoda (Scolopendra sp.), taxa commonly associated with moist soil and leaf-litter microhabitats. Earthworms, in particular, are known soil engineers that contribute to nutrient cycling and soil structure improvement. Their presence confirms adequate soil organic matter and humidity in the campus environment (Sizmur & Richardson, 2020; Vazquez et al., 2024).

Table 3. Wet Preservation of Invertebrate Animals

No.	Phy	Spesies Name	Local Name	Loc.
1	Ann	*Lumbricus terestris*	Cacing tanah	KUT
2	Ann	*Hirudo medicinalis*	Lintah	KUT
3	Mol	*Achatina fulica*	Bekicot	KUT
4	Mol	*Tegillarca granosa*	Kerang dara	TG
5	Mol	*Perna viridis*	Kerang hijau	TG
6	Mol	*Hinia reticulata*	Siput laut	TG/TB
7	Mol	*Loligo sp*	Cumi-cumi	TB
8	Echi	*Asterias sp*	Bintang laut	TB
9	Echi	*Ophiotriix sp*	Bintang ular	TB
10	Echi	*Tripneustes gratilla*	Landak laut	TB
11	Echi	*Echinus sp*	Bulu babi	TB/TG
12	Echi	*Holothuria sp*	Timun laut	TB
13	Arth	*Scylla serrata*	Kepiting bakau	TG
14	Arth	*Litopenaeus vannamei*	Udang	TG
15	Arth	*Scolopendra sp*	Kelabang	KUT

Note:
Phy: Phylum
Ann: Annelid
Mol: Mollusc
Echi: Echinodermate
Arth: Arthropod
TB: Tanjung Bastian
TG: Teluk Gurita
KUT: Kampus Universitas Timor



Figure 3. Wet Preservation of Invertebrate Animals

The preservation protocol—washing, cleaning, boiling, fixation in FAA (Formalin–Acetic Acid–Alcohol) for 24 hours, followed by alcohol storage—proved effective in maintaining specimen morphology (Figure 3). FAA solution is widely used in zoological preservation because it stabilizes cellular structures and prevents rapid decomposition (Ceriaco & Marques, 2025). Subsequent transfer to alcohol enhances long-term storage by inhibiting microbial growth and tissue degradation. Boiling prior to fixation, particularly for soft-bodied organisms (e.g., annelids and mollusks), facilitates tissue relaxation and prevents post-mortem contraction, thereby preserving diagnostic

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morphological features essential for identification and instructional use. (Figure 3). The wet preserved samples were ready to be tested by material experts, media experts, tested by small groups, and tested by large groups. The readiness of wet-preserved specimens for expert validation and group trials demonstrates their feasibility as biology learning media. Real specimens provide tangible observational experiences that enhance student engagement, taxonomic recognition skills, and conceptual understanding of invertebrate diversity. Compared with images or models, preserved biological materials offer authentic texture, structure, and size representation (Wulandari & Andrea, 2025). Furthermore, the inclusion of locally sourced species increases contextual relevance in biology education, supporting place-based learning approaches that connect scientific concepts with students' surrounding environments.

3) *Development Stage*. The development stage is the stage for testing the developed media. The media testing process is carried out to validate the media before distribution to the larger class. The media testing process is conducted with material experts and media experts. The testing of wet-preserved invertebrate media began with validation by material experts on August 11, 2025, using a non-test assessment instrument designed to evaluate media practicality across five indicators comprising 10 statements. The validation results yielded a score of 84%, categorized as valid, indicating that the preserved specimen media were appropriate for instructional use, although several aspects required refinement. Subsequent validation by media experts, conducted on the same date and using a comparable instrument structure, produced a score of 80%, also classified as valid, confirming the feasibility of the media from a design and usability perspective. Expert evaluation notes highlighted specific areas for improvement, particularly the addition of local species names and media usage guidelines to strengthen contextual relevance and user guidance (Table 4). From the media design standpoint, revisions focused on enhancing visual attractiveness through improved color presentation and increasing practicality by separating preserved animals according to species to create a more organized display environment (Table 5). Collectively, these validation outcomes demonstrate that the wet preservation media meet validity standards while emphasizing the importance of iterative refinement to optimize educational effectiveness, usability, and aesthetic quality before broader implementation (Rieger et al., 2022). The evaluation notes from the material experts included.

Table 4. Material validation notes from material experts

No	Section revised	Before	After
1	Text	Local species names should be added	Revised
2	Media Usage Guidelines	Media Usage Guidelines should be added	Revised

Table 5. Media validation notes from media experts

No	Section revised	Before	After
1	Appearance	Colors should be made more attractive	Revised
2	Practicality	Animals should be separated by species for a neater environment	Revised

(Wulandari & Andrea, 2025)

4) *The implementation stage* of the wet invertebrate preservation media was conducted in a small group for trial and a large group. The small group consisted of 20 students from class IIA and class IIC taking an invertebrate zoology course. The testing was conducted using a non-test assessment instrument to assess the practicality of the media. The results of the small group testing revealed normality, homogeneity, item validity, and item reliability.

Prior to large-group implementation, prerequisite statistical analyses were conducted to ensure the feasibility of

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parametric testing through normality and homogeneity assessments. The normality test, performed using the Kolmogorov–Smirnov procedure in SPSS on 20 students from classes IIA and IIC enrolled in the Invertebrate Zoology course, produced a significance value of 0.200 (> 0.05), indicating that the dataset was normally distributed (Table 6); this interpretation was further supported by Shapiro–Wilk results showing Sig. values of 0.668 for both groups. Establishing data normality is essential because it confirms that the distribution of scores approximates a normal curve, thereby meeting assumptions required for subsequent parametric analyses. Furthermore, the homogeneity of variance test, analyzed using Levene's test and ANOVA on the same dataset, yielded a significance value of 1.000 (> 0.05), demonstrating that the variances between the two classes were statistically homogeneous (Table 7). The ANOVA output also showed no variance differences between groups (Sig. 1.000), reinforcing that both samples possessed equivalent variability (Table 8). These findings confirm that the research data satisfied the assumptions of normality and homogeneity, validating their suitability for further effectiveness testing in large groups and strengthening the statistical reliability of the media evaluation results, consistent with standard educational research procedures that require assumption testing before hypothesis analysis (Fahira et al., 2025).

Table 6. Results of the Data Normality Test

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Value	1	.181	10	.200*	.950	10	.668
	2	.181	10	.200*	.950	10	.668

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 7. Results of the data homogeneity test

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Value	Based on Mean	.000	1	18	1.000
	Based on Median	.000	1	18	1.000
	Based on Median and with adjusted df	.000	1	18.000	1.000
	Based on trimmed mean	.000	1	18	1.000

Table 8. Results of the ANOVA test

ANOVA

Value

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	.000	1.000
Within Groups	43.200	18	2.400		
Total	43.200	19			

The instrument feasibility analysis demonstrated that the test items used to evaluate learning outcomes in the large-group implementation met acceptable psychometric standards. The validity test, conducted on 20 questions administered to 10 students from classes IIA and IIC enrolled in the Invertebrate Zoology course, revealed that 15 items were valid based on Pearson correlation significance values, while five items (questions 1, 3, 5, 13, and 18) were invalid and therefore required revision prior to broader use (Table 9). Invalid items generally indicate weak item–total correlations, suggesting misalignment with learning indicators, ambiguous wording, or inappropriate difficulty levels.

Table 9. Question Validity Results

Correlations

		TOTAL
Question 1	Pearson Correlation	.[a]
	Sig. (2-tailed)	.
	N	20
Question 2	Pearson Correlation	.587**
	Sig. (2-tailed)	.006
	N	20
Question 3	Pearson Correlation	.120
	Sig. (2-tailed)	.614
	N	20
Question 4	Pearson Correlation	.674**
	Sig. (2-tailed)	.001
	N	20
Question 5	Pearson Correlation	-.046

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	Sig. (2-tailed)	.847
	N	20
Question 6	Pearson Correlation	.716**
	Sig. (2-tailed)	<,001
	N	20
Question 7	Pearson Correlation	.745**
	Sig. (2-tailed)	<,001
	N	20
Question 8	Pearson Correlation	.568**
	Sig. (2-tailed)	.009
	N	20
Question 9	Pearson Correlation	.772**
	Sig. (2-tailed)	<,001
	N	20
Question 10	Pearson Correlation	.541*
	Sig. (2-tailed)	.014
	N	20
Question 11	Pearson Correlation	.746**
	Sig. (2-tailed)	<,001
	N	20
Question 12	Pearson Correlation	.666**
	Sig. (2-tailed)	.001
	N	20
Question 13	Pearson Correlation	-.006
	Sig. (2-tailed)	.981
	N	20
Question 14	Pearson Correlation	.691**
	Sig. (2-tailed)	<,001
	N	20
Question 15	Pearson Correlation	.640**
	Sig. (2-tailed)	.002
	N	20
Question 16	Pearson Correlation	.550*
	Sig. (2-tailed)	.012
	N	20
Question 17	Pearson Correlation	.552*
	Sig. (2-tailed)	.012
	N	20
Question 18	Pearson Correlation	.223
	Sig. (2-tailed)	.345
	N	20
Question 19	Pearson Correlation	.693**
	Sig. (2-tailed)	<,001
	N	20
Question 20	Pearson Correlation	.501*
	Sig. (2-tailed)	.024
	N	20
TOTAL	Pearson Correlation	1
	Sig. (2-tailed)	
	N	20

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
a. Cannot be computed because at least one of the variables is constant.

Reliability testing further strengthened the instrument's feasibility, with a Cronbach's Alpha coefficient of 0.854 (> 0.60), indicating high internal consistency among items (Table 10).

Table 10. Question Reliability Results

Reliability Statistics

Cronbach's Alpha	N of Questions
.854	20

Following instrument validation, the preserved invertebrate media were implemented in large-class practicum activities consisting of pre-tests, core observational practice examining animal morphological structures using preserved specimens, and post-tests, complemented by student response questionnaires to evaluate media usability and engagement. These findings confirm that the assessment instrument was sufficiently valid and reliable to measure practicum-based learning outcomes and student perceptions, aligning with educational measurement standards that emphasize item validity and reliability as prerequisites for credible evaluation results (Kania et al., 2024; Govindasamy et al., 2024).

5) *Evaluation Phase.* The evaluation phase constituted an advanced stage designed to determine the practicality and effectiveness of the wet invertebrate preservation media following its implementation in a large classroom setting involving 40 Biology Education students enrolled in an Invertebrate Zoology course. Assessment employed both test and non-test instruments, each comprising five indicators with a total of 20 items, to comprehensively measure usability and learning impact (Susiani et al, 2024; Lolowang et al., 2023).

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Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRETEST	65.00	40	14.720	2.327
	POSTTEST	84.50	40	8.608	1.361

Figure 4. Descriptive Analysis of Pretest-Posttest Results

Paired Samples Correlations

		N	Correlation	Significance One-Sided p	Significance Two-Sided p
Pair 1	PRETEST & POSTTEST	40	.814	<,001	<,001

Figure 5. Correlation of Pretest-Posttest Results

Paired Samples Test

		Paired Differences					t	df	Significance One-Sided p	Significance Two-Sided p
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper				
Pair 1	PRETEST - POSTTEST	-19.500	9.185	1.452	-22.437	-16.563	-13.428	39	<,001	<,001

Figure 6. Paired Sample Test Results

The non-test instrument used to measure practicality, along with the test instrument used to measure effectiveness, comprised five indicators with a total of 20 items. The implementation of the wet invertebrate preservation media in the large class (40 students) was intended to evaluate its practicality, effectiveness, and impact based on pretest and posttest results analyzed using a paired t-test. Findings from the practicality and effectiveness assessments, obtained through a questionnaire containing five indicators and 20 items, showed scores of 82% in the "practical" category and 80% in the "effective" category. (Susiani et al, 2024; Lolowang et al., 2023)

Practicality analysis using questionnaire data yielded a score of 82% (practical category), while effectiveness reached 80% (effective category), indicating that the media were functionally feasible and pedagogically beneficial in practicum activities. These results suggest that the wet invertebrate preservation media are easy to use, well-organized, and supportive of practicum implementation, enabling students to conduct observations more systematically and independently. High practicality also reflects clarity of media guidelines, specimen arrangement, and durability of preserved materials, all of which contribute to smoother laboratory management. In terms of effectiveness, the media facilitated meaningful learning experiences by allowing direct examination of morphological structures, thereby strengthening conceptual comprehension and observational accuracy. This finding aligns with instructional media theory, which states that practical and effective learning media enhance student engagement, optimize hands-on activities, and improve the overall quality of science practicum learning processes (Nasution & Taufik, 2025)

Learning outcome improvement was examined through pretest and posttest instruments, where the mean score increased substantially from 65 (pretest) to 84.50 (posttest), reflecting notable cognitive gains following hands-on observation of preserved specimens (Figure 4). Logically, this increase can be attributed to the shift from abstract, theory-based learning toward concrete experiential learning, in which students directly interacted with real biological objects. Through preserved specimens, students were able to observe morphological structures, textures, and anatomical details that are difficult to fully comprehend through textbooks or images alone. This direct sensory

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engagement strengthens memory retention, supports analytical comparison between species, and reduces misconceptions in taxonomic identification. Consequently, the integration of wet preservation media created a more meaningful and contextual learning environment, leading to improved comprehension, higher test performance, and more durable cognitive learning outcomes.

Paired sample t-test analysis further confirmed that this increase was statistically significant, with a correlation significance value of 0.001 (< 0.005), demonstrating a meaningful relationship between media utilization and student achievement (Figure 6). demonstrating a meaningful relationship between media utilization and student achievement. Logically, this statistical outcome indicates that the improvement in posttest scores did not occur by chance but was systematically influenced by the instructional intervention—in this case, the use of wet-preserved invertebrate media. The paired design, which compares the same students' performance before and after treatment, strengthens causal interpretation because it controls for individual differences in prior knowledge and learning ability. Therefore, the significant result reflects the media's direct contribution to enhancing conceptual understanding, observational competence, and practicum engagement. This implies that integrating authentic biological specimens into laboratory instruction creates more effective learning conditions, leading to measurable and statistically verifiable gains in student academic performance. These findings suggest that wet-preserved invertebrate media not only enhance practicum practicality but also significantly improve conceptual understanding and morphological identification skills, supporting constructivist learning principles that emphasize direct experience and concrete learning resources in science education (Rieger et al., 2022).

Proper Care and Maintenance of Wet-Preserved Invertebrate Specimens to ensure that wet-preserved invertebrate specimens—such as those fixed using Formalin–Acetic Acid–Alcohol (FAA) solution—remain well preserved and resistant to deterioration, appropriate procedures must be followed during specimen storage, handling, and maintenance. The following practices are recommended: 1) *Storage in an Appropriate Preservative Solution*: After the fixation process using FAA (Formalin, Acetic Acid, and Ethanol), specimens are generally transferred to a 70% ethanol solution for long-term preservation. The specimen must be completely submerged in the preservative solution to prevent decomposition or deterioration of exposed tissues. 2) *Proper Sealing of the Storage Container*: The storage container should be tightly sealed to prevent evaporation of the alcohol solution. Evaporation can alter the concentration of the preservative, which may cause the specimen to dry out, shrink, or become structurally damaged. 3) *Storage Under Suitable Environmental Conditions*: Specimens should be stored at a stable room temperature (approximately 20–25°C) and protected from direct sunlight. Exposure to ultraviolet (UV) radiation can lead to fading of specimen coloration and may cause tissue structures to become brittle. 4) *Protection from Physical Disturbance*: Containers holding preserved specimens should be handled carefully and protected from shocks, vibrations, or impacts, as these may damage delicate anatomical structures. 5) *Periodic Inspection of the Preservative Solution*: The condition of the preservative solution should be checked regularly. The 70% ethanol solution should be replaced if it becomes cloudy, if its volume decreases due to evaporation, or if noticeable discoloration or deterioration of the specimen occurs. 6) *Durable and Accurate Labeling*: Specimens should be labeled using alcohol-resistant paper and permanent ink to ensure long-term readability. Labels should contain essential information such as specimen identification, collection location, date, and collector details. 7) *Careful Handling During Observation*: When examining the specimens, tweezers or protective gloves should be used to avoid direct contact. Fragile body structures should not be pulled or manipulated excessively. After examination, the specimen should be promptly returned to the preservative solution, and exposure to air

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should be minimized. 8) *Prevention of Contamination*: Contamination must be avoided by ensuring that plain water, other chemical solutions, or newly collected specimens are not introduced into the same storage container. Such practices may lead to microbial contamination and subsequent degradation of specimen tissues (Neumann et al., 2022).

4. CONCLUSION

The development and implementation of wet preservation media for invertebrate animals have been proven to be valid, practical, and effective for supporting invertebrate zoology learning. Validation results from material experts (84%) and media experts (80%), followed by trials in small and large groups, indicate that the media meet feasibility standards for instructional use. Practicality and effectiveness assessments in large-class implementation further demonstrated high values of 82% and 80%, %) scores indicate that the media are feasible to implement and supportive of learning activities. The improvement in student learning outcomes was evident from the substantial increase in mean scores between the pretest (65) and posttest (84.5), with statistical analysis confirming a significant difference and positive correlation (sig. 0.001 < 0.005) verifies that the media contributed meaningfully to students' conceptual understanding and morphological observation skills. These findings collectively affirm that wet-preserved invertebrate media enhance practicum quality, facilitate better conceptual understanding, and significantly improve the learning outcomes of Biology Education students at Timor University.

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6. REFERENCES

Amalia, I., Purwianingsih, W., Kusnadi, Supriatno, B. & Amprasto. (2025). Reconstruction of Laboratory Activity Design Using Vee Diagram Analysis on Blood Type Test Based on ABO System in High School. *Quagga: Jurnal Pendidikan Dan Biologi*, *17*(1), 57–63. https://doi.org/10.25134/quagga.v17i1.342

Aman, A., Tamra, Ramlah, & Makkulawu, R., (2025). Application of the ADDIE Model in the Development of an Android-Based Physics Quiz Game. *Jurnal Krisnadana (Jurnal Komputer, Sistem Kendali, & Jaringan).* 5(1), 69-76. https://doi.org/10.58982/krisnadana.v5i1.949

Ananta ED, Syamswisna, & Ariyati E. (2018). Kelayakan Awetan Basah sebagai Media Pembelajaran Submateri Protista Mirip Tumbuhan. *Jurnal Pendidikan dan Pembelajaran Khatulistiwa.* 7(12), 1-11. https://doi.org/10.26418/jppk.v7i12.30580

Apriatmo Y, Susila HR., & Eriyanti. (2021). Pemanfaatan Media Pembelajaran oleh Guru di SMP Negeri 36 OKU. *Jurnal Lentera Pedagogi.* 5(1), 7-10. https://doi.org/10.54895/lentera.v5i1.887

Artayasa IP, Muhlis M, Ramdani A. (2020) Pembuatan Spesimen Tumbuhan dan Hewan serta Manfaatnya Dalam Pembelajaran IPA SMP. *Jurnal Pengabdian Magister Pendidikan IPA.* 3(20), 156-162. https://doi.org/10.29303/jpmpi.v3i2.519

Atmazak, A., Ramadhan, S., & Indrıyanı, V. (2023). Dialogic-Interactive Media in Online Learning: Effectiveness in Speaking Skills. *Turkish Online Journal of Distance Education*, 24(4), 95-111. https://doi.org/10.17718/tojde.1146195

Ceriaco, L.M.P., & Marques, M.P. (2025). Fluid-preserved zoological specimens in Portuguese Natural History collections: a historical overview and implications to collection management and research. *Natural History Collections and Museomics* 2: 1–69. https://doi.org/10.3897/nhcm.2.142114

Darrigran G, Agudo-Padrón I, Báez P, Belz CE, Cardoso F, Carranza A, Collado GA, Correoso M, Cuezzo MG, Fabres AA, et al. (2025). Molluscs from South America to the

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 2, 2026, pp 96 - 111
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: https://doi.org/10.25134/quagga.v18i2.513

World: Who and Where Are They? *Biology*. 14(11):1538. https://doi.org/10.3390/biology14111538

Delgado, S. G., Bilbao, E. L., Hardisson, A., Paz, S., Weller, D. G., Rubio, C., & Gutierrez, A. J. (2024). Metal concentrations in echinoderms: Assessing bioindicator potential and ecological implications. *Marine Pollution Bulletin*, 205. 116619, https://doi.org/10.1016/j.marpolbul.2024.116619

Dewi, S.A. & Carolina, H.S. (2024). Development of Interactive Flipbook-Based Learning Media on Cell Material Class XI Students SMA N 01 Kotagajah. *Quagga: Jurnal Pendidikan Dan Biologi*, *16*(2), 160–167. https://doi.org/10.25134/quagga.v16i2.134

Fahira, S. I., Dewi, I. P., Al-Adwan, A. S., & Castro, R. C. (2025). Augmented Reality to Enhance Informatics Learning Outcomes: A Quasi-Experimental Study in Vocational Education. *Journal of Hypermedia & Technology-Enhanced Learning*, 3(2), 185–201. https://doi.org/10.58536/j-hytel.167

Fahriza, N., Sunandar, A., & Rahayu, H. M. (2023). Development of a Pocket Book Based on Mind Mapping on Material Classification of Class VII Living Things. *Quagga: Jurnal Pendidikan Dan Biologi*, *15*(2), 131–139. https://doi.org/10.25134/quagga.v15i2.25

Fikriyya N, & Sulistiyawati S. (2019). Pengembangan awetan invertebrata disertai panduan praktikum sebagai sumber belajar. *Prosiding Symbion (Symposium on Biology Education).* 2(1), 115-125. 2540-752X. https://doi.org/10.26555/symbion.3515

Fitria, S., Wulandari, M., & Sahrul. (2025). Analisis Statistik: Uji Validitas Reliabilitas Instrumen Indeks Efektivitas Tujuh Standar Pendidikan Akademi Kepolisian (IEPA). *Jurnal Teknologi Pendidikan*, 3(2), 13. https://doi.org/10.47134/jtp.v3i2.2236

Govindasamy, P., Cumming, T. M., & Abdullah, N. (2024). Validity and reliability of a needs analysis questionnaire for thedevelopment of a creativity module. *J Res Spec Educ Needs*. 24. 637-652. https://doi.org/10.1111/1471-3802.12659

Hardila, D., & Vebrianto, R. (2024). Validity of student creativity test instruments on energy and its changes for junior high school students. *Jurnal Mangifera Edu*, *9*(1), 56-63. https://doi.org/10.31943/mangiferaedu.v9i1.190

Kamaluddin & Hano'e EMY. (2022). Pelatihan Pembuatan Insektarium Bagi Siswa SMA/SMK Kecamatan Insana Utara. *Jurnal Pengabdian Sains dan Humaniora.* 1(2), 58-65. Doi: https://doi.org/10.32938/jpsh.1.2.2022.58-65

Kania, N., Kusumah, Y. S., Dahlan, J. A., Nurlaelah, E., Gí¼rbí¼z, F., & Bonyah, E. (2024). Constructing and providing content validity evidence through the Aiken's V index based on the experts' judgments of the instrument to measure mathematical problem-solving skills. *REID (Research and Evaluation in Education),* 10(1), 64–79. https://doi.org/10.21831/reid.v10i1.71032

Laksana, D. N. L. (2024). Validation Instruments for Local Culture-Based Learning Media. *Journal of Education Technology,* 8(2), 264–274. https://doi.org/10.23887/jet.v8i2.74446

Lang BJ, Donelson JM, Bairos-Novak KR, Wheeler CR, Caballes CF, Uthicke S, Pratchett MS. (2023). Impacts of ocean warming on echinoderms: *A meta-analysis. Ecol Evol.* 8;13(8):e10307. doi: https://doi.org/10.1002/ece3.10307

Lestari R. (2020). Pengembangan Media Pembelajaran Spesimen Vertebrata Dan Invertebrata Untuk SMA Negeri 2 Rambah Hilir. *Bio-Lectura*. 7(1), 36–42. https://doi.org/10.31849/bl.v7i1.4005

Lolowang, Y., Arrijani, & Ogi, N.L.I.M. (2023). Effectiveness of Practicum Activities as an Effort to Improve Student Learning Outcomes at SMA Negeri 2 Tondano. *Jurnal Arjuna: Publikasi Ilmu Pendidikan, Bahasa, dan Matematika.* 1(5), 160-170. https://doi.org/10.61132/arjuna.v1i4.

Macri, S. & Di-Poi, N. (2024). The SmARTR pipeline: A modular workflow for the cinematic rendering of 3D scientific imaging data. *iScience*. 27. 111475. 1-17. https://doi.org/10.1016/j.isci.2024.111475

McAleer, P., Tetzel, C. K., & Paterson, H. M. (2021). Year 2 Research Methods and Statistics Practical Skills (1.0.9001). Zenodo. https://doi.org/10.5281/zenodo.5101080

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 2, 2026, pp 96 - 111
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: https://doi.org/10.25134/quagga.v18i2.513

Musfirah, N., Nurbaya, Nursalam, Akbar Rasyid. (2025). Pengembangan Instrumen Hasil Penilaian Belajar Tes dan NonTes. *In Socius: Jurnal Penelitian Ilmu-Ilmu Sosial* (Vol. 2, Number 11, pp. 120–125). Zenodo. https://doi.org/10.5281/zenodo.15534085

Nachman M. W., Beckman E. J., Bowie R. C., Cicero C, Conroy C. J., Dudley R, et al. (2023) Specimen collection is essential for modern science. *PLoS Biol* 21(11): e3002318. https://doi.org/10.1371/journal.pbio.3002318

Neumann, D., Carter, J., Simmons, J.E., & Crimmen, O. (2022). *Best Practices in the Preservation and Management of Fluid-Preserved Biological Collection.* SPNHC: London. https://spnhc.org/preservation-and-management-of-fluid-preserved-biological-collections/

Pangsuma, N. Surakusumah, W. & Sanjaya, Y. (2024). Comparative Study of Learning Models and Teaching Materials on Student Cognitive Learning Outcomes. *Quagga: Jurnal Pendidikan Dan Biologi*, *16*(2), 108–117. https://doi.org/10.25134/quagga.v16i2.127

Rahayoe AS. (2019). Kombinasi Alkohol dan Asap Cair Sebagai Alternatif Pengawet Spesimen Cacing Tanah (Pheretima sp.). *Indonesian Journal of Laboratory.*1(3):1-7. https://doi.org/10.22146/ijl.v1i3.48715

Rieger, O. Y., Schonfeld, R. C., & Sweeney, L. (2022). The Effectiveness and Durability of Digital Preservation and Curation Systems. *ITHAKA S+R*. https://doi.org/10.18665/sr.316990

Ryanto, R., Wojayanti, A.T., Widiastuti, A., & Riadi, A. (2025). The Effectiveness of Learning Media in Overcoming Learning Difficulties: Student Perceptions. Jurnal Pemberdayaan Masyarakat, 4(1), 169-180, https://doi.org/10.46843/jpm.v4i1.413

Saydah, A., Fakhruddin, Z. & Irianti, M. & Nor, M. (2024). Validity Test and Practicality Test of Virtual Reality Based Learning Media on Optical Equipment Material. *Journal of Educational Sciences*, 8(3), 476-487. https://doi.org/10.31258/jes.8.3.p.476-487

Sinaga, A. A., Jumadi, J., Suyanta, S., Khaerunnisa, N. ., & Rejeki, S. . (2023). Effectiveness Test Application Lectora Inspire as Science Learning Media for Upgrade Concept understanding Student. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4205–4210. https://doi.org/10.29303/jppipa.v9i6.2806

Sitompul, A. F., & Siregar, E. H. (2020). Analysis of the Quality of Local Potential-Based Invertebrate Preservation Media for Invertebrate Taxonomy Course. *J. Phys.: Conf. Ser.* 1462 012062. https://doi.org/10.1088/1742-6596/1462/1/012062

Sizmur, T., & Richardson, J. (2020). Earthworms accelerate the biogeochemical cycling of potentially toxic elements: Results of a meta-analysis. *Soil Biology and Biochemistry*. 148, 107865, https://doi.org/10.1016/j.soilbio.2020.107865

Stepnicka, Z., Piorkowska, N., Brozyna, M., Matys, T., & Junka, A. (2025). Systematic Review of Artificial Intelligence use in behavioral analysis of invertebrate and larval model organisms: Methods, Applications and Future Recommendations. *bioR*. 14. 1-50. https://doi.org/10.1101/2025.10.16.682789

Suci, T. P., & Sunismi, S. (2024). Validity Test of Android-Based Learning Media Assisted by Ispring Suite on Pythagorean Theorem Material. Prisma Sains: *Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, 12(2), 296–305. https://doi.org/10.33394/j-ps.v12i2.8676

Susiani, Jamilah, Mustami, K., Syahriani, & Nugraha, A.F.E. (2024). Genetic Box: Character, Validity, Practicality, and Effectiveness as A Learning Media. *Quagga: Jurnal Pendidikan Dan Biologi*, *16*(1), 1–11. https://doi.org/10.25134/quagga.v16i1.17

Talikan, A. I., Salapuddin, R., Aksan, J. A., Rahimulla, R. J., Ismael, A., Jimlah, R., Idris, N., Dammang, R. B., Jamar, D. A., Sarahadil, E., & Ajan, R. A. (2024). On Paired Samples T-Test: Applications, Examples and Limitations. Ignatian International Journal for Multidisciplinary Research. 2(4), 943–

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 2, 2026, pp 96 - 111
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: https://doi.org/10.25134/quagga.v18i2.513

951. https://doi.org/10.5281/zenodo.10987546

Usman, M., Sari, W. O. S. M., Fitrianingsih, Tahir, M. R., Arni Nur Laili, & Muhammad Fadillah. (2025). Pelatihan Penggunaan Instrumentasi Non-Tes bagi Guru Bimbingan dan Konseling di SMA Negeri 5 Kendari. *Indonesia Berdampak: Jurnal Pengabdian Kepada Masyarakat*, 1(1), 82-89. https://doi.org/10.63822/r3e09w93

Vaughn, S.N., & Jackson, C.R. (2022). Evaluating Methods of Preserving Aquatic Invertebrates for Microbiome Analysis. *Microorganisms*, 10, 811, 1-15. https://doi.org/10.3390/microorganisms10040811

Vazquez, E., Arango, J., & Pulleman, M., & Teutscherova. (2024). The role of earthworms in grasslands: Earthworms and Ecological Processes. *Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas (ETSIAAB)*. 265-290. https://doi.org/10.1007/978-3-031-64510-5_9

Wahid, S. (2025). Analysis of Student Learning Outcomes According to the Implementation of the Project Based Learning. *JPERR: Journal of Physics Education: Review and Research.* 2(1), 1-5. https://doi.org/10.35580/jperr.v2i1.8326

Woa AS, Dua Dhiu K, & Oka GPA. (2022). Pengembangan Media Pembelajaran Flash Card Untuk Meningkatkan Kemampuan Kognitif Pada Anak Usia Dini di Paud Terpadu Citra Bakti. *JCPA (Jurnal Citra Pendidikan Anak).* 1(1), 159-171. https://doi.org/10.38048/jcpa.v1i2.753

Wulandari, A., & Andrea, S. N. V. (2025). Development of Preserved Resin Specimen of Arthropod Fauna Blocks as a Media for Biology Learning. *APPLICATION: Applied Science in Learning Research*, *4*(3), 113–120. https://doi.org/10.32764/application.v4i3.5623