JURNAL BIOEDUIN

p-ISSN : 2338-7173
e-ISSN : 2615-0417
(Februari 2025), Vol.(15), No.(1)

Development of Vertebrate Material Instruments to Improve Scientific Literacy

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Abstract

Theoretically, full-day school education practices should be able to reduce the impact of 21st-century pandemics. One of the most important aspects that should be instilled from the early stages of education is scientific literacy. In this study, an instrument was developed and validated to measure junior high school students' biological literacy. The development followed the ADDIE model. The instrument was based on the 2013 Science Curriculum for Grade VII Biology and comprised eight literacy elements related to biology. Among the 20 topics addressed, five were classified as nominal literacy, seven as functional, four as structural, and four as multidimensional biological literacy. Logistic validity assessments were conducted for content, construct, and language aspects by three validators, and the results were analyzed using Aiken's V formula. The validation results indicated that the instrument had a very high level of validity across all aspects, while the practicality tests by both teachers and students showed that the instrument was highly practical and easy to use. Therefore, the instrument is considered valid and practical, making it suitable for use in the learning process to measure students' scientific literacy on vertebrate material.

Keywords: assessment, instruments, scientific literacy, vertebrates

INTRODUCTION

Science education has an important role in shaping students' understanding of scientific concepts, including the world of vertebrate fauna (Ridwan & Ramdhan, 2021) . Vertebrates are a group of animals with backbones, including various types of animals such as mammals, birds, reptiles, and fish. A good understanding of vertebrates is not only helpful in a scientific context but also in forming environmental awareness and animal conservation (Rachma, 2023) .

Scientific literacy skills are very relevant to learning vertebrate material because they involve understanding scientific concepts, interpreting data, and analyzing and synthesizing information (Fadilah et al., 2020) . By developing scientific literacy instruments that focus on vertebrate material, it is hoped that students can optimize science learning and increase their understanding of the complex world of vertebrates(Pertiwi et al., 2018) .

The development of scientific literacy instruments for vertebrate material is also in line with efforts to increase students' overall scientific literacy (Lopez de Aguileta, 2019) . Scientific literacy is an important skill in facing the increasingly rapid development of science and technology. With a

p-ISSN : 2338-7173
e-ISSN : 2615-0417
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structured and valid scientific literacy instrument, teachers can carry out a comprehensive evaluation of students' ability to understand and analyze scientific information about vertebrates (Kristyowati & Purwanto, 2019).

Apart from that, the development of scientific literacy instruments for vertebrate material can also be a means of measuring the effectiveness of science learning in achieving predetermined learning goals (Nurazizah et al., 2022). With an instrument that can measure students' understanding holistically, teachers can evaluate the success of the learning process in transferring knowledge about vertebrates to students well (Hanbidge, 2018).

A thorough understanding of vertebrates is helpful not only in the academic realm but also in increasing students' awareness of the importance of biodiversity and environmental protection(Niate & Djulia, 2022). Through strong scientific literacy in vertebrate material, it is hoped that students can become agents of change who care about the preservation of vertebrate fauna and their habitats. Thus, developing scientific literacy instruments for vertebrate material is a strategic step in increasing students' understanding and awareness of biodiversity and the importance of animal conservation (Selegi, 2019).

RESEARCH METHODS

The method used in this research is development research (Research and Development). This research is a development study or R&D (*Research and Development*) with reference to the ADDIE model (Putri et al., 2022). The ADDIE model is an abbreviation for Analyze, Design, Development, Implementation, and Evaluation. The stages carried out in research using the ADDIE model are the analysis stage, design stage, development stage, implementation stage, and evaluation stage(Krismona Arsana & Sujana, 2021). The following is the RnD procedure using the ADDIE approach.

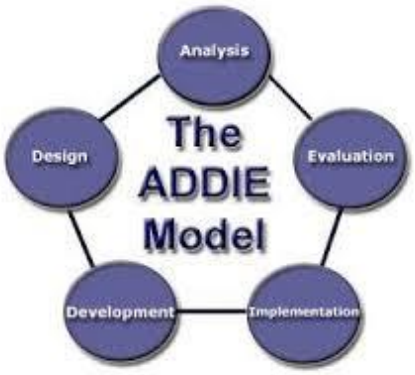

Figure 1. ADDIE model

The analysis stage carried out includes core competency analysis, fundamental competency analysis, and determining critical thinking indicators related to invertebrate topics). *The Design* Stage (Design) involves designing the test instrument grid. The Development stage involves developing test instruments based on the grid and preparing the assessment rubric. The *Implementation* stage involves testing the test instruments on students. *The Evaluation stage* assesses the suitability and accuracy of *the analysis, Design, Development,* and *Implementation stages,* as well as calculating the validity and reliability of the test instruments (Waldi et al., 2022).

p-ISSN : 2338-7173
e-ISSN : 2615-0417
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1. Analyze
The initial stage began with a learning needs analysis, which involved identifying the actual conditions in the field and determining the needs of teachers and students regarding a science literacy test instrument on the theme *Vertebrates: Our Friendly Environment*. In addition, an analysis was carried out on core competencies, basic competencies, and critical thinking indicators relevant to the theme of learning.

2. Design
In this stage, the researcher began to design the test blueprint based on the results of the previous analysis. The design process was supported by literature and input from academic advisors, teachers, and peers. The structure of the instrument included a cover page, instructions for students, test material, science literacy elements, individual assignments, and a back cover.

3. Development
The test instrument was developed into 15 essay questions covering three sub-themes: the relationship between humans and the environment, environmental changes, and environmental conservation efforts. The questions were constructed based on Bloom's taxonomy from C1 (knowledge) to C5 (evaluation). A scoring rubric was also prepared at this stage. The instrument was validated by subject matter experts, language experts, and media/design experts.

4. **Implementation**
After validation, the instrument was tested on eighth-grade students at SMP Negeri 1 Teluk Pinang. The trial was conducted in two stages: one-on-one trials and small group trials. Students were also asked to complete a questionnaire to assess the ease of use and clarity of the instrument. Teachers also provided feedback on practicality using an evaluation form.

5. Evaluation
The instrument was comprehensively evaluated based on expert validation results and the outcomes of the trial implementations. The evaluation stage in this study was conducted comprehensively to ensure the validity and practicality of the developed science literacy test instrument. The evaluation was carried out by three experts, namely a content expert, a language expert, and a media/design expert. Each expert was given a validation questionnaire consisting of 35 items using a Likert scale to assess the quality of the instrument from various aspects. The aspects evaluated included content feasibility (alignment of the test items with the basic competencies and the vertebrate theme), language aspects (clarity of sentences, readability, and accuracy of language usage), as well as design or media aspects (visual appearance, print quality, efficiency of image and text use, and format consistency).
Science Literacy Instrument Grid:

No	Aspect	Indicator
1	Scientific competencies	Explaining the phenomenon
		Using evidence and data scientifically
		Identifying scientific questions
2	Scientific knowledge	Understand the phenomenon
3	Scientific contexts	Problem-solving

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e-ISSN : 2615-0417
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RESULTS AND DISCUSSION

Development of scientific literacy test instruments. The final product of this research is a test instrument based on scientific literacy on the theme of vertebrates (Widayat et al., 2014)(Parlan et al., 2019) for class VIII school students junior high school SMP 1 Teluk Pinang (Nengsih et al., 2022). The test instrument used in this research is essay-based questions on scientific literacy (Pursitasari et al., 2019). In the development of ADDIE, there are several stages, namely: *analysis stage*, stage *design*, *development stage*, and evaluation stage (Latief (Latief et al., 2022). The author went through these stages so that the scientific literacy test instrument on the theme of our friend Vertebera for class VIII students was valid and practical. Following These stages, The writer:

Stage Analysis

At the analysis stage, several initial studies were conducted to support the development of relevant and contextual science literacy instruments. Concept analysis was conducted by identifying the main material related to the theme of "vertebrates" in the subject of science for grade VIII, which includes sub-themes such as types of vertebrates, environmental changes, and efforts to preserve living things. Furthermore, curriculum analysis was conducted based on the 2013 Curriculum, focusing on relevant Core Competencies and Basic Competencies, especially those that require scientific thinking, analysis, and problem-solving skills. Researchers also conducted student competency analysis by examining the needs and characteristics of students through informal interviews with science teachers and documentation studies of previous learning outcomes. Findings from this stage indicate that students still have difficulty in answering questions that require science literacy skills, especially in linking biological concepts to real problems in the surrounding environment. Therefore, a test instrument is needed that not only measures factual knowledge, but also high-level thinking skills such as analysis, data interpretation, and scientific reasoning in the context of everyday life.

The initial stage of developing a scientific literacy test instrument is a needs analysis. Needs analysis: The products developed are related to actual conditions in the field according to the needs (Widiatno & Nurlaela, 2019). Analysis learning needs is the stage of finding out about the product in the form of a scientific literacy test instrument (Herlina Kurniati & Achmad, 2023), which is needed by teachers and students on the theme of our friend's environmental vertebrates for class VIII students at SMP Negeri 1 Teluk Pinang.

Stage Design (Planning)

Test instrument design process**:** Before researchers start developing the test instrument design, first researchers understand how to develop from several references regarding making test instruments. (Fakhriyah et al., 2019). Suggestions from supervisors and teachers were beneficial to researchers, who are beginners in developing teaching materials (Deliany et al., 2019). Before the validation process, researchers also asked for input from several friends as well as a number of Teachers about the instrument test that was developed(Awami et al., 2022). The following is a form preparation instrument test literacy science, which a researcher wants to make.

Table 1. Instrument of Literacy Science

No	Element Test Instrument	Description Instrument Test
1.	*Cover* front	page front containing title, class, identitystudent, Education logos,

p-ISSN : 2338-7173
e-ISSN : 2615-0417
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		And Name author
2.	Instruction General	Contains instruction for students in use test literacy science
3.	Instruction workmanship student	Contains instruction method processing question by student as well as time processing
4.	Material	Thematic material for class VIII vertebrates
5.	Literacy Learning science	Which hook material learning with literacy skills owned student so that student capable answer question based on proof actual Which There is in the environment surroundings
6.	Task Individual	The test is given after learning the vertebrate theme finished
7.	*Cover* rear	As cover behind

Stage Development (Development)

The instrument test developed become 15 question items description, with details as follows:

1) The five-item question subtheme is one man and environment.

2) Five item question subtheme two change environment.

3) Five-item question subtheme effort preservation environment.

Instrument test Which used covers domain cognitive C1 until C5, that is knowledge (C1), understanding (C2), application (C3), analysis (C4) And evaluation (C5).

At the development stage, the test instrument was designed based on international scientific literacy indicators, particularly those used in the Programme for International Student Assessment (PISA). The scientific literacy indicators used encompass three main aspects: (1) scientific content, which involves students' knowledge of scientific concepts and facts; (2) scientific processes, which assess students' ability to identify questions that can be scientifically investigated, design experiments, and interpret data; and (3) scientific situations, which relate to students' ability to apply scientific concepts to real-life situations. Based on the developed test blueprint, a total of 15 items were constructed and distributed as follows: five questions measured content aspects, five assessed process skills, and five evaluated application in contextual situations.

It is important to note that in the earlier version, the indicators used were predominantly based on the cognitive domain of Bloom's taxonomy (C1–C5), such as knowledge, comprehension, and evaluation. These indicators are more representative of cognitive learning outcomes rather than comprehensive scientific literacy indicators. This creates a discrepancy between the research title, which claims that the instrument aims to assess scientific literacy, and the actual content of the instrument, which focuses more on measuring cognitive learning achievement.

Therefore, if no revisions are made to the indicators and items to better reflect scientific literacy, it is advisable to revise the research title to accurately reflect the actual focus for instance: "Development of an Assessment Instrument for Students' Cognitive Learning Achievement in Vertebrate Materials." However, if the intention is to maintain a focus on scientific literacy, then the

p-ISSN : 2338-7173
e-ISSN : 2615-0417
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indicators and item development must be aligned with internationally recognized scientific literacy frameworks such as PISA or NOS (Nature of Science).

Stage Implementation (Application)

The test instrument developed in this study underwent a validation process before being applied in the learning trial. The validation was carried out by a team of experts consisting of a content expert, a language expert, and a media/design expert (Fadilah et al., 2020). Each expert assessed specific aspects according to their field of expertise, such as content accuracy, language clarity, and the appropriateness of the visual design. The validation results indicated that the instrument met the eligibility criteria and was categorized as excellent. Following the validation process, the instrument was tested on eighth-grade students at SMP Negeri 1 Teluk Pinang in two stages: a one-on-one trial involving four students, and a small group trial involving eight students (Sharma et al., 2019).

In each trial stage, students were asked to answer the questions in the test instrument and complete a questionnaire. The questionnaire was designed to collect data on students' perceptions of question clarity, ease of answering, and the overall attractiveness of the instrument. The purpose of the trial was to determine whether the instrument was ready for use or required further revision (Kristyowati & Purwanto, 2019). Two types of questionnaires were used in this study: a validation questionnaire and a practicality questionnaire (Ulfah et al., 2020). The validation questionnaire was given to expert validators to assess the validity of the instrument in terms of content, language, and design, while the practicality questionnaire was given to teachers and students to evaluate the ease of use and usefulness of the instrument in learning activities. The results of these questionnaires were analyzed both qualitatively and quantitatively as the basis for revising and improving the instrument before wider implementation. Description questionnaire evaluation validity instrument test and practicality instrument test as follows:

a. Results test Validation test instrument

The validation assessment questionnaire in this study consisted of 35 questions arranged on a *Likert scale* with answer categories 5, 4, 3, 2 and 1 with the criteria respectively very good, good, quite good, not good, and No good (Hasdiana, 2018). Based on results from evaluation expert material, which has been analyzed for the know-validity instrument test literacy science(Pertiwi et al., 2018), results validation has been analyzed as follows:

Table 2. The Results of validation expert Aspects of material feasibility

Aspect Which rated	*Indicator Value Assessment*	*/ Category Score*	
Aspects of material feasibility	The questions correspond to vertebrate material	**5**	**Very good**
	Question and answer boundaries are clear	**3**	**Pretty good**
	The content of the material corresponds to vertebrates	**4**	**Good**
	The content of the material is appropriate to the type of school or grade level	**4**	**Good**

p-ISSN : 2338-7173
e-ISSN : 2615-0417
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Formulation of the question or question sentence	**4**	**Good**

Based on the expert assessment results, the material has been analyzed to determine the validity of the instrument test literacy science (Untari et al., 2018) for results validation, which has been analyzed as follows.

Table 3. The Results of validation expert Aspects of Design

Aspect Which rated	***Indicator Value Assessment***	***/ Category Score***	
Design	Quality paper that is used	**4**	**Good**
	Presentation covers, list fill, and instrument test	**4**	**Good**
	Appearance size And form question	**4**	**Good**
	Suitability design instrument test with characteristics material	**4**	**Good**
	Quality of interior design form book simple and interesting	**4**	**Good**
	Consistency appearance design	**4**	**Good**
	Type And size letter used	**4**	**Good**
	Efficiency question and picture	**4**	**Good**
	Order presentation	**4**	**Good**
	Results print and binding	**4**	**Good**
	Appearance physique	**4**	**Good**
	Total	**44**	**Good**

Based on the overall assessment of the validity of the scientific literacy test instrument given by the three experts, namely language experts, material experts, and media experts scientific literacy test instruments on the theme of vertebrates for class VIII students of SMP Negeri 1 Teluk Pinang (Sapti et al., 2019). Recapitulation of the overall results of the validity assessment from three experts can be seen in the following table:

Table 4. Results Response Team Expert

No	**Validator**	**The score obtained**	**Average**	**Category**
1	Design	44	4	Very Good
2	Language	56	4.3	Very Good
3	Contents/ Material	52	4.7	Very Good
	Total	**152**	**4.3**	**Very Good**

Based on the table above, an average of 4.3 is obtained, which falls into the x category > 3.4, with the information being very good or valid (Fadilah et al., 2020). Therefore, the scientific literacy test instrument is theme VIII. Our friend's environment for class VIII students of SMP Negeri 1 Teluk Pinang was declared valid in terms of language validity. Based on the table above, material analysis obtained an average of 4.7, which included category x > 3.4 with excellent information or can be said to be valid. Therefore, the scientific literacy test instrument for class VIII students of

p-ISSN : 2338-7173
e-ISSN : 2615-0417
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SMP Negeri 1 Teluk Pinang was declared valid in terms of validity material (Deliany et al., 2019). Based on the table above, media or design analysis is obtained from an average of 4 who went inside category $x > 3,4$ with very Good or valid information (Herlanti, 2015).

Results Test Practicality Teacher and Student

1) Test Practicality Teacher

The practicality test of the teaching materials was carried out with Mrs. Supartiyah. As a class VIII teacher at SMP Negeri 1 Teluk Pinang, on the teacher practicality sheet, there are 11 questions to be a teacher's guide to assessing the developed scientific literacy test instrument. The following are the results of the teacher's response after using a scientific literacy test instrument on theme VIII, our friend's environment for class VIII students. The aspects provided through the teacher response sheet were categorized as very practical. Results recap Teacher can see on evaluation questionnaire open as follows:

Table 5. Results Analysis Test Practicality Teacher

Code Teacher	Qty. Score	Category
Guardian class	52	Very practical
Average	4.7	Very Practical
Results	94,5%	Very Practical

Based on the results of the teacher practicality questionnaire which is obtained, it can be concluded that the teacher's response towards contextual-based companion book teaching materials is efficient, with a percentage of 94.55%, so that material taught can be used in the process of learning (Pertiwi et al., 2018).

2) Test Practicality student

Based on the questionnaire given to students in this *one-to-one test* and small group test, they showed very positive results on the scientific literacy test instrument (Solikhin & Wijanarko, 2021) Student results on *one-to-one tests* and tests group small can seen on the evaluation questionnaire as follows:

Stage Evaluation (Evaluation)

The development of scientific literacy test instruments on the environmental theme of our friends is evaluated at stage validation by media experts, language experts, and material experts. The analysis stage is carried out in accordance with the applicable curriculum (Widayat et al., 2014). Evaluation of the validity of the scientific literacy test instrument is carried out by conducting an evaluation expert team (Ariyanti et al., 2020). The expert team's evaluation was carried out by three experts, namely design experts, language experts and material experts. Evaluation results team experts form questionnaires to become standard benchmarks, which is an instrument test that is developed to be valid or not (Nursyifa & Masyithoh, 2023).

The following are the results of revisions from experts after receiving input and suggestions, being revised or repaired in accordance with suggestions and input from experts(Latief et al., 2022) described in detail in Table 4.11 below:

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e-ISSN : 2615-0417
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Table 6. Revision from Team expert validation

No	Validation	Before revision(expert advice)	After revisi (result revision)
1.	Expert Language	1. Understand usage. Which is effective? 2. understand usage read, And method typing. 3. Numbering	1. Use sentence-effective Language. Which standard, in accordance 2. Use sign read And method typing Already repaired 3. Numbering Already repaired
2.	Expert material	1. Take note of effective sentences when making questions 2. *Typo* (there is an error writing in the sentence) 3. Answer limits must be customized with a question	1. The effectiveness of the sentence 2. Used has been repaired. Repair letter typo or writing error already repaired 3. The answer is limited customized with question
3.	Expert media	1. The picture on the front is not enough 2. Background colour consistency written (dark vs bright) 3. Quality on picture Which used (dark vs bright)	1. Picture on cover front moment in print the quality Already repaired 2. Use color background on instruments accordance suggestion 3. Use quality pictures on the question instrument tes that have been repaired in accordance with the suggestion

The trial of the science literacy test instrument in the learning process was carried out through various classroom activities, including question-and-answer sessions, individual assignments, and group discussions related to the topic “Our Vertebrate Friends” as reflected in the test content (Kumalasari & Poedjiastoeti, 2023). These interactive methods allowed researchers to observe how students engaged with the test items in a real classroom setting, thereby providing contextual insights into the practicality and relevance of the instrument. Through this process, it was evident that the test items stimulated students to think critically, connect biological concepts with real-life contexts, and articulate scientific reasoning, all of which are key components of science literacy

The implementation of the instrument in these learning activities also served to evaluate its feasibility and effectiveness in a classroom setting. Based on the results of the trials and expert validation, the instrument was deemed both **valid and practical** for use in science education at the junior high school level (Sapti et al., 2019). The positive responses from students and teachers, as well as the successful integration of the instrument into instructional practices, affirm that the test can function not only as an assessment tool but also as a learning support that encourages students to apply scientific concepts meaningfully.

CONCLUSION

Based on the results of research and development (R&D) with the title "Scientific literacy test instrument on theme 8, our friends' environment for class VIII students of SMP Negeri 1 Teluk Pinang "produces material products teaching in the form of test instruments that are valid and practical to use. This research has gone through the validation stage by experts consisting of

p-ISSN : 2338-7173
e-ISSN : 2615-0417
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language experts, material experts, and media experts, as well as one-to-one trials, small trials, and teacher practicality tests. The overall results of expert validation are valid, so it is suitable to be tested in *one-to-one trials* and small-group trials. Results Practicality The teacher and student gave an excellent response to the Instrument test literacy science, which was developed and stated that it is convenient for use.

Study This is a study development to give suggestions for the needs utilization of the products produced. The product resulting from this research is expected to become a reference Teacher class VIII in activity learning.

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