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Development of Scientific Literacy Test Instruments for Ecotourism-Based Field Practicum Students Prospective Biology Teachers

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Abstract: This development research aims to assess the validity and reliability of scientific literacy measurement instruments based on bird ecotourism that are feasible, effective, practical, and receive positive student responses. The research design uses the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation. Data was collected using Observation, interview, test, questionnaire, and documentation methods. Data analysis was carried out quantitatively on scientific literacy measurement instruments' validity, reliability, and practicality by calculating the average score and determining the criteria at certain class intervals. The results show that the scientific literacy measurement instrument is valid, reliable, and effective in improving the scientific literacy of prospective science-biology teacher students, so it is suitable for use in learning. The reliability of the scientific literacy skills (SLS) test is 0.94 (very good). The N-gain value for the SLS post-test in the experimental class was 71, while the N-gain value for the control class post-test was 63. The difference test results using the Mann-Whitney test were obtained from Asymp. Sig. 0.038 ≤ 0.05. This means there is a significant increase in the ability of experimental class students to SLS after learning activities. Student responses to EBFP-M were recorded as 24 people (86%) giving positive assessments (good and very good), and the implementation of 13 aspects (81%) of the 16 aspects measured was good.

Keywords: Ecotourism; Instruments; Measurement; Scientific Literacy.

Introduction

The level of science literacy and inquiry of science teachers is still relatively low. Tiered training for teachers only increased science literacy by 1% and inquiry literacy by 5% [1]. The strength of science lies in the ability to formulate hypotheses that encourage the development of various students' thinking abilities [2]. The ability of students to master and study science is closely related to the very rapid development of science and technology, so students must have good scientific literacy skills [3]. Scientific literacy is essential in biology education because it helps students understand biological concepts, conduct research, and make evidence-based decisions. This becomes even more relevant when associated with ecotourism, a form of sustainable tourism that focuses on preserving the environment and biodiversity. Students with good scientific literacy will be able to actualize their knowledge in solving problems through critical thinking and a positive attitude [4]. People with sound science and technology skills can solve problems using scientific concepts and create creative product technologies [5]. In the era of rapidly developing information and technology, scientific literacy is one of the key competencies that prospective biology teacher students must possess. Scientific literacy plays a role in understanding science concepts and is essential for developing critical attitudes and analytical thinking skills in dealing with various complex scientific issues. Therefore, educational institutions must ensure prospective teachers have adequate scientific literacy.

The importance of mastering by students illustrates that this scientific literacy ability is fundamental, especially for all stakeholders involved in education, to meet life's needs in various situations. Thus, educators' knowledge of integrated scientific learning and literacy concepts is an essential asset in improving the quality of teaching and learning in the classroom [6].

Human life today is facing drastic changes. And complex in various aspects. These changes are not enough to be faced by relying on conventional thinking skills; scientific literacy skills are needed. This is crucial for every success because it increases competitive advantage, productivity, overcoming problems or failures, and boredom [7]. Scientific literacy is needed to succeed in the 21st century [8]. The results of scientific literacy tests show that it is still at the nominal, functional, conceptual, and procedural levels but has not yet reached the multi-dimensional level [9]. In line, reported that 95.5% of students had low reasoning abilities and were categorized as concrete and transitional reasoners [10]. Only 4.5% of students reached the formal operational reasoning category. However, there are currently significant challenges in measuring the scientific literacy of prospective biology teacher students. The lack of valid and reliable instruments to measure this competency is

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one of the main obstacles. Existing instruments often cannot comprehensively describe aspects of scientific literacy, such as understanding, analyzing, and applying scientific information. In addition, many instruments are not adapted to the context of biology education, so the measurement results do not reflect students' abilities.

The existence of valid instruments is essential to provide constructive feedback to students and lecturers, as well as to formulate effective learning strategies. Without the right measurement tools, it will be challenging to determine how students have developed their scientific literacy and how it affects the quality of teaching they will do in the future. Therefore, the development and validation of appropriate and relevant scientific literacy measurement instruments for prospective biology teachers are essential to improve the quality of education and prepare competent teachers in the field of science. To overcome this, students must be given several experiences to master biological concepts with fun and joyful learning through ecotourism-based field practicums. This model aligns with the statement that there are four sources of human knowledge in the learning process: philosophy, theory, empirical research results, and empirical experience [11]. Therefore, ecotourism-based field practicums are thought to achieve learning objectives in science and biology effectively.

Students can utilize ecotourism activities in several Biology Education Study Program courses as field practicum activities. One of the ecotourism objects currently popular with many tourists is birds. The *M. reinwardt* bird can be used as a tourist attraction because it is unique, its limited distribution has high economic value, and its natural habitat is in a tourist area. In this regard, it is feared that its population will decrease drastically and disappear from Lombok Island. Therefore, research on the ecotourism-based field practicum model (EBFP-M) is essential, in addition to improving scientific literacy and critical thinking skills of prospective teacher students, as well as a conservation strategy for *M. reinwardt* which is starting to become rare, support empowerment and economic development of the community [12-13]. Ecotourism positively impacts the preservation of the environment and local culture, and it is ultimately expected to foster identity and pride among residents who grow due to increased ecotourism activities. Since 2014, tourism has become the second largest source of state revenue after taxes, including ecotourism [14].

Research methods

This study is development research using the ADDIE model, namely Analyze, Design, Development, Implementation, and Evaluation. At the analysis stage, core competency analysis, fundamental competency analysis, and determining scientific literacy indicators related to bird ecology are carried out. The Design stage creates a SLS test instrument grid; The Development stage compiles 25 multiple choice questions; The Implementation stage conducts a trial of the SLS test instrument on 55 prospective biology teacher students, FKIP, Mataram University, Academic Year 2023/2024. The Evaluation stage assesses the suitability and accuracy of the Analyze, Design, Development, and Implementation stages. It measures the validity and practicality of the test, as well as the responses of prospective biology teacher students.

The research data was analysed qualitatively by describing the data resulting from expert validation. The results and validity scores given by the experts were calculated and analyzed to determine the validity level criteria of the developed test instrument. Validated aspects There are three, namely material covering four aspects, construction, five aspects, and language, three aspects. The calculation of content validation from the validator uses the formula Score = Validator score/maximum score x 100% [15]. The scores from the validator are then averaged and described in depth. The SLS test script was validated by six experts in biology and learning technology and 40 students to assess the feasibility, effectiveness, practicality, and student responses. The instrument is declared feasible if the average value of the feasibility validation results is more than three on a scale of one to five.

Results and Discussion

This research comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The following is a description of the research results obtained from each stage of development.

Analyst Stage

At this stage, the results of the identification of two topics of field practicum activities based on *M. reniwardt* bird ecotourism, namely Observation of habitat recognition and characteristics of M. reinwardt nests, there are five SLS indicators measured in students, namely 1) explaining phenomena scientifically; 2) evaluating and designing scientific investigations, interpreting data and evidence scientifically; 3) Application of science in everyday life; 4) Showing an attitude of interest in science that plays an essential role in decision making; and 5) Showing a creative attitude, providing innovative ideas based on logical thinking and scientific knowledge. Furthermore, to measure students' SLS against the five indicators, 25 multiple-choice questions were made.

Design Stage

Developing an assessment to measure scientific literacy through field practicums based on M. reinwardt bird ecotourism is a crucial step in improving students' understanding and awareness. At this stage, first, clear learning objectives are determined. These objectives focus on increasing students' knowledge of the M-reinwardt bird ecosystem and increasing students' SLS. Furthermore, developing observation sheets, grids, SLS test questions, and validation sheets based on scientific literacy and ecotourism indicators. This rubric is designed to provide constructive feedback to students, helping them understand strengths and weaknesses that need improvement.

The product's components and initial design stages are developed through validation by experts from different fields. Furthermore, the design that has been made has been validated by six experts to obtain input and determine the feasibility of improving the draft manuscript. The experts selected are four lecturers from the University of Mataram, one person from the Biology Study Program, Faculty of Science and Technology, UIN Syarif Hidayatullah Jakarta, and one lecturer from the Mandalika University of Education. Validators have expertise in ecology, Science Education, learning media, evaluation, scientific literacy skills, and critical thinking skills. On the assessment sheet of the validated instrument, a place is provided for the validator's assessment and notes. Validators can provide evaluations, notes, comments, and suggestions for improving the device. From these activities, it is hoped that the SLS measurement assessment developed will be valid, feasible, and practical.

Development Stage

At this stage, validation of the SLS measurement instrument was carried out. Before the revision was approved by the validator with several notes and inputs. The following is a summary of the input and results of qualitative and quantitative validation from expert validators on the draft instrument presented in Table 1.

Table 1 above shows that the expert validator's response to each correction instrument is minor, such as clarifying the cover image of the guide, increasing the image's resonance, writing, choosing diction, explaining the purpose, and others. All input from the expert validator has been accommodated to improve the SLS instrument. All expert validators assessed that the developed SLS measurement script was suitable for use in measuring the SLS of prospective science teacher students. The results of the quantitative assessment from the expert validator on the SLS Measurement Instrument and its supporting devices are presented in Table 2.

Table 1. Summary of Input from Expert Validators

No	Validated Instruments	Expert Validator Comments and Suggestions
1	Pre-test and post-test scripts for scientific literacy and critical thinking skills	• Some diction has been replaced; for example, the word "die" in question number 6 has been replaced with "perish," the descriptive word number 24 has been replaced with the word "component," a typo, etc.; • Some questions are not related to the MPLBE topic need to be adjusted; • It is worth considering creating five answer options;
2	Scientific literacy development-oriented learning questionnaire	• Provide space for notes at the questionnaire's end to accommodate things not included in the statement items.
3	Lecture Program Unit (SAP)	• It is attempted to include SLS skill indicators at each stage of learning.

Table 2. Summary of Average Scores of Validation Results of SLS Measurement Instruments, Student Responses, Learning Implementation, and SLS Observation Forms by Expert Validators

Validators	CLICK	Student Response	Learning Implementation Questionnaire	SLS Observation For
1	4.5	4.0	4.2	4.4
2	4.2	4.3	4.2	4.4
3	4.3	4.2	4.3	4.3
4	3.8	4.0	4.0	4.2
5	3.8	3.9	4.1	4.1
6	4.4	4.2	4.3	4.5
Total	25.06	24.6	25.1	25.9
Average	4.2	4.1	4.2	4.3

Description: SLS = Scientific Literacy Skills
K

The validation results by expert validators on the four instruments in Table 2 above obtained an average score of between 4.1–4.3, classified as "very good." The SLS measurement instrument and the Student Response questionnaire obtained the lowest score of 3.8 (good) and the highest score of 4.8 (very good) with an average of 4.2, classified as "very good." As for the aspects assessed in each instrument, the number varies between four and 16 aspects. The Student Response questionnaire has 16 aspects, the SLS test script has 12 aspects, and the SLS observation form has four aspects. The scores for each element of the instrument are presented in Figure 1.

Based on Table 2 and Figure 1 above, it can be seen that the MPLBE guideline score is between 3.8 and 4.8, with an average of 4.2, which is classified as "very good." The minor score is 3.8 for the MPLBE cover, resonance, and image colour. However, it is still classified as "good." Regarding the input from the validator, the image quality has been improved and aligned with the theme of the EBFP-M activity event. The validation score for the aspects assessed against the SLS and KBK test script instruments, the lowest score is 3.8 (good) for the aspectlimitn questions and answers that are expected to be precise. The summary of the recapitulation results and average scores of each instrument are presented in Figure 1.

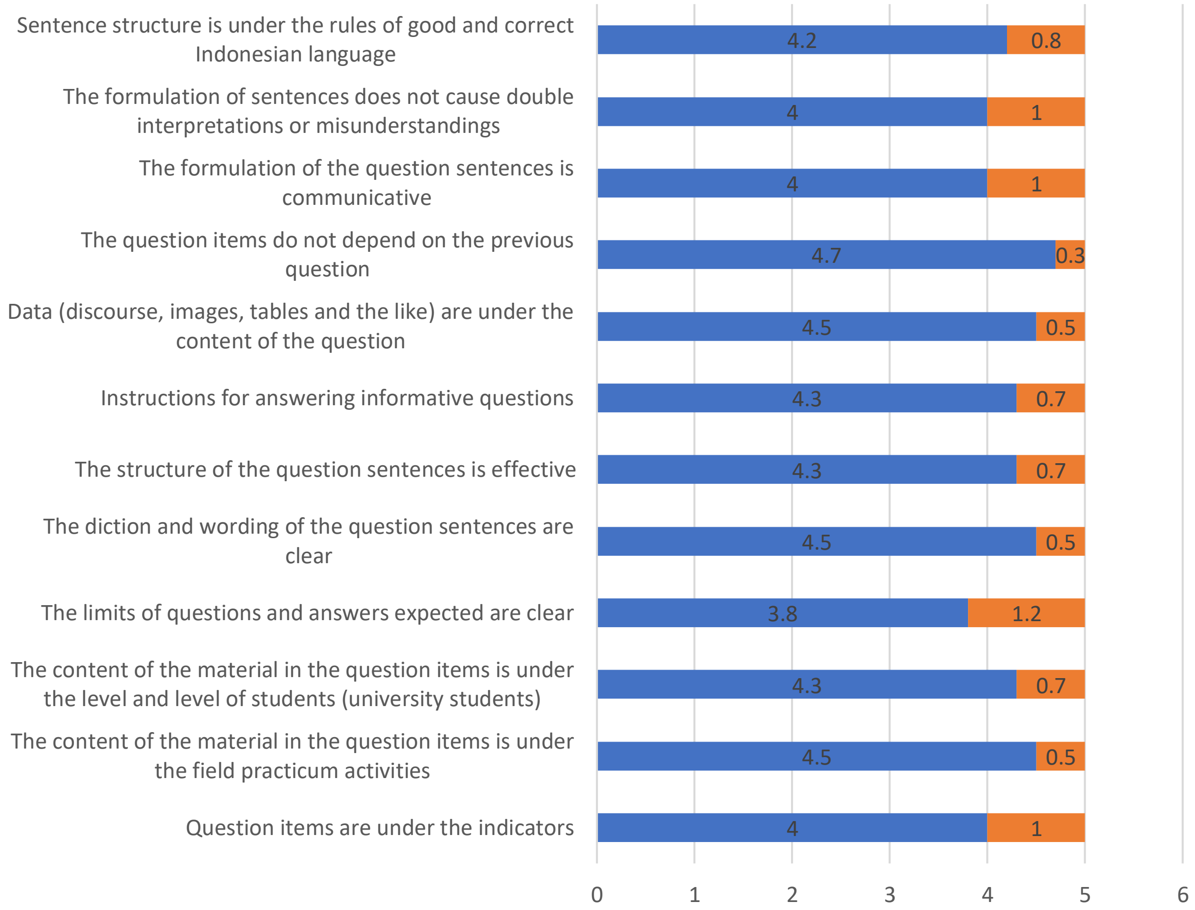

Figure 1. Average Validation Score of Aspects Assessed in the SLS Instrument Manuscript

Furthermore, regarding the analysis of the SLS pre-test questions, the results need to be revised on questions number 2 and number 42 because they are invalid, and the discrimination power is classified as poor. The reliability of each test meets the value requirements of 0.83 for prerequisite questions and 0.94 for SLS questions. The SLS pre-test and post-test questions originally numbered 27 to 25 multiple-choice questions with five options. There are 25 SLS questions. The design The SLS measuring instrument script that has been validated and revised according to expert input is then tested on a limited scale.

Implementation Stage

At this stage, the SLS test instrument was tested on 55 Biology Education Study Program students, FKIP, Mataram University, Academic Year 2023/2024. The SLS test was given before and after students carried out field practicum activities based on Edan and conducted observations regarding the natural habitat and characteristics of the M. reinward bird's nest in two field visits. The time required to conduct observations, observations, and measurements totaled 360 minutes or 7JP (2 x 180 minutes).

Evaluation Stage

The scientific literacy skills measured include six indicators, namely (1) explaining scientific phenomena scientifically; (2) evaluating and designing scientific investigations; (3) interpreting data and evidence scientifically; (4) applying science in everyday life; (5) showing an attitude of interest in science which plays an essential role in decision making; and (6) showing a creative attitude, providing innovative ideas based on logical thinking and scientific knowledge. (Attachment 3). The measurement was conducted with a written test before (Pre-test) and after (Post-test) the EBFP-M activity using 25 multiple-choice questions with five options. In addition to the measurement through a written test, it was also conducted through Observation during the MPLBE activity process, assisted by a practicum assistant at each stage of the EBFP-M by referring to the SLS observation sheet the researcher had prepared. A summary of the results of the SLS measurement through written tests and observations in the EBFP-M activity is presented in the following table.

The results of observations on the indicators of students' scientific literacy skills during the implementation of EBFP-M in Table 3 above recorded four indicators: observing, classifying, and communicating. More than 60% of student practitioners carried out observation results well. The SLS indicator "collecting or writing complete and precise observation results was carried out well by 20 students (71%). Presenting, discussing, and concluding the results of observations of as many as 15 people (54%) and the classification of observation results was carried out independently by 18 students (43%). One of the four indicators, namely the skill of predicting things that might happen, was carried out well by 12 students (43%). From these data, it can be interpreted that the majority (52.7%) of prospective Biology teacher students at FKIP University have scientific literacy skills in the good category, 25.9% in the poor category, and 12.5% in the low category. These results are not much different from those reported, that students' scientific literacy skills are still below the criteria of being lacking, which is indicated by students' skills in understanding research methods leading to scientific knowledge of 59.54%, and skills in organising, analysing, and interpreting quantitative data [16]. In this regard, reported that students' scientific literacy skills in several sub-indicators include 1) Evaluating and using scientific information 79 (good), 2) Understanding research design elements and predicting their impact on scientific discoveries 28 (very poor), 3) Making graphs that can represent data 28 (very poor), 6) Reading and interpreting data 56 (poor), 7) Problem-solving using quantitative skills 33 (very poor), 8) Understanding and being able to interpret basic statistics 24 (very poor), 9) Presenting conclusions, predictions based on quantitative data 31 (very poor) [17-18]. Students' scientific literacy abilities regarding basic biological concepts for both competencies are dominated by the nominal category with a percentage range of 62%, in the functional category 34%, and in the conceptual category, in the range of 4% - 7% [19].

The results of the analysis of the SLS written test conducted on the six indicators and each indicator, specifically between the control class and the experimental class, are presented in Table 4 below.

Table 3. Observation Results of the Dominant Implementation of SLS in EBFP-M on Prospective Science-Biology Teacher Students 2024

No	Scientific Literacy Skills Indicators	Skor			∑ Students.	%
		1	2	3		
1	**Observing:**					
	Using measuring tools	5			5	17.9
	Reading measurement results		3		3	10.7
	Collecting or writing down observation results			20	20	71.4
2	**Classifying:**					
	Identifying Habitat Components	4			4	14.3
	Tabulating observation results		9		9	32
	Classifying observation results			15	15	53.6
3	**Predict:**					
	Using the results of observations to predict an object or	3			3	10.7
	phenomenon and stating things that might happen in situations		13		13	46.4
	that have not been observed.			12	12	42.9
4	**Communicating**					
	Serve,			12	12	42.9
	discussion, and		4		4	14.3
	conclusion from observation results	2			2	7.1

Data source: Researcher's observation results (Appendix 24)

Information:
Observation: 1=collect incomplete observation results; 2 = collect complete observation results; 3 = collect complete, relevant, and precise observation results.
Classifying: 1 = Tcannot classify the results of his observations; 2 = classification of the results of his observations with the help of a lecturer; 3 = classification of the results of his observations is done independently.
Predicting: 1 = cannot use the results of observations to predict what might happen; 2 = can use the results of observations to predict what is possible; 3 If he can use the results of his observations to predict and put forward what might happen in a situation that has not been observed.
Communicating: 1 = presenting, discussing, and concluding the results of observations is unclear; 2 = discussing the conclusion of the observation results is not clear; 3 = presenting, discussing, and the conclusion is clear.

Table 4. Results of Pre-test and Post-test, SLS, and N-Gain of Experimental Class and Control Class of Prospective Biology Teacher Students 2024

	Experimental Class					Control Class				
	Pre-test	Posts	g	N-gain (%)	Category	Pre-test	Posts	g	N-gain (%)	Category
ID	28	28				27	27	-	-	-
∑	1082	1999	949	1580	-	1052	1695	837	1378	-
Average	38.6	71.3	34	57	Currently	39	63	31	51	Currently
Mom	62	98	66	92	-	54	85	64	86	-
Min.	18	42	18	18	-	24	41	15	14	-
Mann-Whitney Test Pre-test Asymp. Sig. 0.673										
Mann-Whitney Post-test Asymp. Sig. 0.038										

Information: Criteriaa decision is made if the value: %g > 70 is high, 30 ≤ %g < 70 is medium, and %g < 30 is low [20].

Based on Table 4, the average score of the N-gain pre-test SLS of the experimental class students was 38, and the average score of the pre-test of the control class was 39. Furthermore, to determine the significance of the difference in N-gain SLS between the two classes, a difference test was carried out using the Mann-Whitney Test, considering that the two samples were not normally distributed and the numbers were different. The difference test results on the average N-gain pre-test scores of the experimental and control classes obtained a value ofAsymp. Sig. 0.673. If the value of Asymp. Sig. ≤ 0.05 means there is a difference in scientific literacy skills between the experimental and control classes [21]. Based on these criteria, the initial abilities of students in both the experimental and control classes before the MPLBE learning process are not significantly different (Table 4).

The average N-gain post-test of the experimental class was 57%, while the average N-gain post-test of the control class was 51%. The results of the difference test of the N-gain post-test between the two classes using the Mann-Whitney Test were obtained. Sig. 0.038 ≤ 0.05. This means there is a significant difference in SLS between the experimental and control classes. Thus, it can be said that there is a substantial increase in the ability of SLS of experimental class students after EBFP-M activities. Half of the students achieved the scientific literacy standard (69.23%), and most (93.7%) of the students agreed that the experimental model was helpful and wanted to apply it for the following activities [22].

Of the 28 participants in the experimental class, eight out of 15 people were recorded whose N-gain percentage was classified as ineffective, six out of four people were in the reasonably effective category, and eight out of six people were in the effective category. Meanwhile, of the 27 participants in the control class, the N-gain was divided into three categories: five high, six medium, and 16 low participants. The increase in the average N-gain percentage score in the experimental class was 57%, which is included in the reasonably effective category. In comparison, the increase in the control class was 51%, which is included in the ineffective category.

The results of the difference in the average N-gain pre-test scores of the experimental and control classes obtained a value ofAsymp. Sig. 0.673. If the value of Asymp. Sig. ≤ 0.05 means there is a difference in scientific literacy skills between the experimental and control classes. Based on these criteria, the initial abilities of students in the experimental and control classes before the EBFP-M learning process are not significantly different (Table 4). The average N-gain post-test of the experimental class was 57, and the control class average N-gain post-test was 51. The results of the N-gain post-test difference test between the two classes using the Mann-Whitney Test obtained Asymp. Sig. 0.038 ≤ 0.05. This means there is a significant difference in SLS between the experimental and control classes. Thus, it can be said that the test script is significantly effective in measuring the SLS of prospective science teachers in the experimental class after the EBFP-M activity. The scientific literacy ability of prospective biology teacher students at FKIP Unram in the control class was recorded at a score of 39 - 51. The SLS of Indonesian students was 47 to explain and 35 to evaluate. Furthermore, Li noted that the SLS of Indonesian students was 48-50 [23].

Student responses to the statement items in the questionnaire (Appendix 7) show a change in the attitude of respondents in the experimental class who previously disagreed with the addition of practicums in the Zover lecture and considered the lecture to be sufficient with three credits to concur with the practicum activity of 1 credit. This shows that students enjoy the practicum activities during the Zover lecture. This attitude correlates with the results of the quantitative analysis, which shows an increase in the average N-gain percentage score in the experimental class by 57%. Likewise, the attitude of students in the control class towards the addition of practicum activities tends to agree, and the learning outcomes of students in the control class also experienced an increase in the average N-gain percentage score of 31%. Interpretation of the results of the analysis of students' perceptions of the bioecology of the *M. reinwardt* bird before and after the implementation of EBFP-M is shown in Table 5 below.

Table 5. Summary of Results of Analysis of Student Perceptions on the Bioecology of the Bird *M. reinwardt* Before and After Implementation of EBFP-M

Aspects measured	Control (%)		Experiment (%)		Control (%)		Experiment (%)	
	Positive	Negative	Positi	Negative	Positive	Negati	Positive	Negati
Exploration of biotic components	41	59	27	73	90	10	55	45
Exploration of abiotic components	54	46	62	38	84	16	70	30
Data Measurement	52	48	39	61	69	31	66	34
Classification	58	42	77	23	80	20	70	30
Disclosure of bioecological characteristics of M. reinwardt	65	35	60	40	90	10	40	60

Table 5 above shows a change in perception in both experimental and control class students who tended to be more optimistic than before the intervention, except for the disclosure of bioecological characteristics of birds *M. reinwardt* control class decreased/became negative. Aspect disclosure of the bioecological attributes of the bird *M. reinwardt* shows changes in student responses before and after the intervention. Students in the control class before the implementation of learning showed a positive attitude of 60%, but after learning, students changed their perceptions to 40% (Table 5). This indicates that there are inappropriate learning stages in the control class. The most significant increase in positive perceptions occurred in exploring biotic and abiotic components in the experimental class, respectively, from 41 to 90 and

54 to 84.

Conclusion

Based on the research results and discussion above, it can be concluded: 1) Development of SLS measurement assessment is carried out in five stages, namely: analysis, design, development, implementation, and evaluation of ADDIE). 2) The SLS measurement instrument is valid, reliable, practical and effective so that it is suitable for use in learning and can improve scientific literacy skills and critical thinking skills of prospective IIPA teacher students.

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