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Application-Assisted PBL-STEM Model Hinbiodiv to Improve Students' Science Literacy in Biodiversity Material

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Abstract

The low level of students' scientific literacy is one of the problems that needs to be solved. This study aims to analyze the application of the Hinbiodiv-assisted PBL-STEM model in improving students' scientific literacy in biodiversity material in high school. The research method used is a quasi-experimental design with a non-equivalent control group design. The research sample included class X MIPA 4 as a control class totaling 37 students and class X MIPA 1 as an experimental group totaling 34 students. The data collected were in the form of increasing students' scientific literacy by distributing questionnaires to students. The data analysis of this study used the normality test, Walcaxon test, Man Whitney test, and N-Gain test. The results showed that the Implementation of the Hinbiodiv-Assisted PBL-STEM Model could improve students' scientific literacy in the experimental class with an N-Gain value of 0.79 in the high category, while in the control class with the conventional method the N-Gain value was 0.46 in the moderate category. So it can be concluded that the application of the Hinbiodiv-Assisted PBL-STEM Model is recommended for use in biology learning in high school to improve scientific literacy.

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INTRODUCTION

The Problem Based Learning (PBL) learning model is one of the appropriate models for solving a problem (Puspita Sari et al., 2017). This model is a type of cooperative learning designed to influence student interaction patterns that aim to improve students' scientific literacy so that it can ensure the involvement of all students and increase individual responsibility in the group. Problem Based Learning (PBL) integrated with Science, Technology, Engineering, and Mathematics (STEM) is expected to help improve student learning achievement, especially at MAN 2 Surakarta, Madrasah Aliyah Negeri (MAN) is a level of formal education in Indonesia which is equivalent to Senior High School (SMA). because this learning model emphasizes students to be active individually and in groups so that the teaching and learning process takes place effectively. Further explained in the research of Afriana et al. (2016) that STEM integrated PBL can improve scientific literacy and interesting learning. This generation is able to think and behave scientifically by applying scientific literacy directly (Linder et al., 2014). The integration of STEM aspects can have a positive impact on learning, especially in terms of improving student learning outcomes in the fields of science and technology. His is what is called scientific literacy; where this ability is in the form of understanding science in written or oral form and being able to apply it in everyday life (Yulianti, 2017).

21st century education is currently a new challenge for the world of education, due to the rapid advancement of technology and globalization. 21st century learning is a transition from 19th century learning which is still centered on teachers to student-centered learning (Fahrozy et al. , 2022). This means that students become active subjects in learning, have the skills to find the core of the topic being studied; have the ability to utilize technology and multimedia; have collaboration skills; and provide freedom in choosing learning for students (Ginting, et al., 2021).

According to the National Literacy Movement Guidelines of the Ministry of Education and Culture, there are six bases or scopes of digital literacy, namely reading and writing literacy, digital literacy, and numeracy literacy, digital literacy, cultural literacy, citizenship literacy, andscientific literacy (Syafrial, 2023), this is a complement to science learning through project activities that integrate engineering science, technology, and mathematics. Urrently, the scope of scientific literacy is the main goal in science education (Pratiwi et al., 2019). Based on the statement above, scientific literacy can develop knowledge, mindset, draw conclusions based on facts, problems, and phenomena in the natural environment in everyday life. Scientific literacy is a person's ability to read, identify, understand, and utilize scientific concepts to adapt and solve everyday life problems (Fakhriyah, et al., 2023).

One of the biology materials presented in the 2013 Curriculum in the odd semester of grade X is biodiversity. Biodiversity material whose learning process requires students to improve their skills and knowledge in solving problems related to the topic, so teachers are required to improve the quality of their learning. Biodiversity is still a fairly complex problem due to the lack of public awareness in efforts to preserve it. Therefore, this awareness needs to be increased by providing comprehensive education and socialization, both through the formal education curriculum in schools and non-formal programs in the community. Learning plays an important role in developing a positive attitude of caring for the environment through learning such as in the school environment. Good utilization of the environment in Elementary Schools can help teachers in delivering learning materials or information, so that it can foster good student enthusiasm, and can foster creative ideas from students in their learning (Wahid, et al. 2020).

In this effort, effective learning media assistance is needed. One of the learning media that can be used is the hinbiodiv application which is expected to improve students' scientific literacy skills. This Hinbiodiv learning media is a tool to help convey messages in the learning process. The Hinbiodiv application is a modification of the iSpring Suite into an interactive application. Interactive technology-based learning such as Hinbiodiv can improve scientific literacy because students are more actively involved in the learning process and can connect the concepts learned with real situations in their environment (Gunawan et al., 2020).

Based on the description above, it is emphasized that research needs to be conducted because it aims to analyze the application of the PBL-STEM model assisted by the Hinbiodiv application to improve science literacy in students on biodiversity material in high school. This is supported by the results of research (Putri et al., 2020) that the implementation of STEM-PBL received a positive response from students through their great attention to the STEM-PBL activities and assignments they did. This research is expected to improve science literacy in students, student skills to improve the quality of learning related to biology learning and students' science literacy attitudes.

METHOD

The research method used is quasi-experimental with nonequivalent control group design. The population of this study were all students of class X MIPA MAN 2 Surakarta. The research sample included class X MIPA 4 as the Control class totaling 37 students and class X MIPA 1 as the Experiment class totaling 34 students. The research instruments used were questionnaires and tests. The pretest was given before the treatment, then compared with the ability after being given treatment with the posttest.The instruments used are valid and reliable based on the assessment of material experts and media experts.

This research was conducted in 3 stages, namely preparation, implementation, and development of instruments (questionnaires) to measure students' scientific literacy. After that, an evaluation of the questionnaire's feasibility was carried out with a validity and reliability test. Validity means how appropriate the measuring instrument developed is to measure something that is to be measured (Widoyoko, 2016). Then the score data obtained is then interpreted using the reliability criteria according to Arikunto (2016). At the research implementation stage, quantitative and qualitative data collection was carried out by providing a pretestat the beginning of learning to measure students' initial abilities, then provide a posttestin the form of a questionnaire at the end of learning. Quantitative data generated from the pretest and posttest are usually in the form of numbers, such as grades or scores given to students based on test results. To remind students of scientific literacy in the material of biodiversity. In the final stage, data interpretation was carried out to obtain a picture of the level of scientific literacy of MAN 2 Surakarta students in the material of biodiversity using the STEM-based PBL Model. Indicators of scientific literacy according to Gormally, et al. (2012) presented in Table 1.

Data analysis to measure the level of students' scientific literacy is carried out with the following steps: 1) determining the score related to students' scientific literacy results by giving a value to each indicator. If the student answers correctly, it will be worth 1 and if the student answers incorrectly, it will be worth 0, 2) Adding up the scientific literacy scores obtained by each student based on the data obtained from the results of the responses to each student's learning indicators, 3) Changing the total score into a value in the form of a percentage using the formula:

$$Persentase\ (\%) = \frac{Total\ Score}{Maximum\ Total\ Score} \times 100\%$$

To analyze learning completeness, the pretest and posttest results were arranged in percentage form and then tabulated based on the criteria presented in Table 2.

Table 1. Indicators of Scientific Literacy

No	Variables
1.	Identifying appropriate scientific arguments
2.	Use effective literature search
3.	Evaluation in the use of scientific information
4.	Understanding design research
5.	Create a graph that can represent data
6.	Reading and interpreting data
7.	Problem with solution
8.	Understand and be able to interpret basic statistics
9.	Presenting conclusions

Table 2. Learning Completion Criteria

Interval of Science Literacy Test Score	Category
81< %≤100	Very high
61< %≤80	Tall
41< %≤60	At the moment
21< %≤40	Low
0< %≤20	Very Low

From the results of the normality and homogeneity tests, it is known that the data shows abnormal results, therefore the data is tested using the Mann-Whitney and Walcoxon test analysis. Based on the results of the normality test, the pretest The value of scientific literacy in the experimental group and the control group p value 0.055 <0.05 and 0.014 <0.05, which means that the data is not normally distributed, while the results of the posttest normality test of scientific literacy in the experimental group and the control group obtained a p value of 0.000 <0.05 and 0.001 <0.05, which means that the data is not normally distributed, so a non-parametric test is carried out, namely the Mann-Whitney test, this test is an alternative to the independent t-test when the normality assumption is not met. The provisions of the Mann-Whitney test include: 1)

If the sig. value (2-tailed) > α (0.05) then Ho is accepted, and 2) Ifsig. value (2- tailed) < α (0.05) then Ha is accepted. Based on the test resultsMann-Whitney pretest of students' scientific literacy was obtainedp-value 0.915 < 0.05 which means there is no difference in the pretest of student creativity between the experimental group and the control group, while the results of the Mann-Whitney posttest of student science literacy obtained a p-value of 0.007 < 0.05 which means there is a difference in the posttest value of student creativity between the experimental group and the control group.

The Wilcoxon test is used to test the difference between two paired data samples. The Wilcoxon test has the following provisions: 1) If the sig. value (2-tailed) > α (0.05) then Ho is accepted, 2) Ifsig. value (2-tailed) < α(0.05) then Ha is accepted. Based on the results of the Walcoxon test of students' scientific literacy, it is known that the p-value is 0.000 <0.05, which means that there is a difference between the creativity of the pretest and posttest students in the experimental group. Then it is known that the p-value is 0.98 <0.05, which means that there is no difference between the creativity of the pretest and posttest students in the control group. After the Wilcoxon test was conducted, the N-Gain test was conducted to determine the extent to which scientific literacy had increased in students. The N-Gain score formula is the reduction of the posttest and pretest scores compared to the difference between the maximum score and the pretest score. Then the N-Gain score criteria are explained qualitatively based on Table 3.

Table 3. N-Gain Value Criteria

Indicator		Information
g>0.7	:	Height increase
0.3≤g≤ 0.7	:	Current improvements
Profit N <0.3 g <0.3	:	The increase is low.

RESULT AND DISCUSSION

Average Student Science Literacy Score

The assessment of scientific literacy is obtained from the results of the answers to scientific literacy questions that have been worked on by students based on the assessment rubric. In accordance with the opinion that states that a test instrument is said to be appropriate if the assessment of all aspects, namely the topic aspect, scientific literacy, construction, and grammar by experts is good (Adawiyah & Wisudawati, 2018). The following are the average pretest and posttest scores for scientific literacy in the experimental group and the control group presented in Table 4.

Table 4. Average Scores of Science Literacy Pretest and Posttest

Group	Average	
	Pre-test exam	Post-test exam
Test	36.85	81.88
Control	36.43	74.46

The average value of scientific literacy in the experimental group increased after being given learning using the STEM-based PBL Model assisted by the Hinbiodiv application on biodiversity material, namely from 21.79 to 81.11. Meanwhile, the average value of scientific literacy in the control group using regular learning also increased, namely from 21.59 to 72. The increase in the value of scientific literacy in the experimental group increased by 59.79, which means it is higher than the increase in the value of scientific literacy in the control group, namely 50.41.

Differences in Science Literacy Between the Experimental Group and the Control Group

The difference in science literacy between the experimental group and the control group was determined using the Man-Whitney test from the pretest and posttest scores presented in Tables 5 and 6.

Table 5. Differences in Science Literacy Pretest between Experimental Group and Control Group

Group	Pre-Test Science Literacy	p Value	Important Values	Conclusion
Test	21.79	0.792	0.05	No difference
Control	21.59			

The results of the statistical test obtained a p-value of 0.792 < 0.05, which means that there was no difference in the science literacy pretest between the experimental group and the control group.

Table 6. Differences in Science Literacy Posttest between the Experimental Group and the Control Group

Group	Post-Test Science Literacy	p Value	Important Values	Conclusion
Test	81.11	0.000	0.05	There is a difference
Control	72			

The statistical test results obtained a p-value of 0.000 <0.05, which means that there is a difference in the post-test value of scientific literacy between the experimental group and the control group. Before and after being given the PBL-STEM learning model treatment assisted by the Hinbiodiv application and in the control group with learning using the lecture method or usually analyzed using the Wilcoxon Test because it was not normally distributed. The results of the analysis are presented in Table 7.

Table 7. Differences between Pre-test and Post-test Science Literacy in Experimental and Control Groups

Group	p Value	Sig Value	Conclusion
Test	0.000	0.05	There is a difference
Control	0.792	0.05	No difference

The results of the study showed a p value of 0.000 <0.05, so Ho was rejected and Ha was accepted, which means there was a difference between the results of the pretest and posttest of scientific literacy in the experimental group. Then a p value of 0.792 <0.05 was obtained, which means there was no difference between the results of the pretest and posttest of scientific literacy in the control group.

Completion of Science Literacy of Students in Experimental Group and Control Group

The level of students' scientific literacy before and after the study can be seen in Table 8. Table 8 shows that the category of values before the study in the experimental class was dominated by the very low category of 55.88%, the same as the control class which was dominated by the very low category of 64.86%. While the value after the study showed the potential of the PBL-STEM learning model assisted by the Hinbiodiv application on students' scientific literacy, the category of scientific literacy values in the experimental class was dominated by the very high category with a percentage of 61.76%, the same as the control class which was dominated by the very high category with a percentage of 45.95%.

Table 8. Categories of Science Literacy Before and After Research

	Interval of Science Literacy Test Score	Category	Group Experiment		Group Control	
			Frequency	%	Fequency	%
Before	81< %≤100	Very high	number 0	number 0	number 0	number 0
	61< %≤80	Tall	number 0	number 0	number 0	number 0
	41< %≤60	Currently	1	2.94	2	5.41
	21< %≤40	Low	14	41.18	11	29.73
	0< %≤20	Very Low	19	55.88	24	64.86
	Total		34	100	37	100
After	81< %≤100	Very high	21	61.76	17	45.95
	61< %≤80	Tall	10	29.41	10	27.03
	41< %≤60	Currently	3	8.82	7	18.92
	21< %≤40	Low	number 0	0.00	3	8.11
	0< %≤20	Very Low	number 0	0.00	number 0	0.00
	Total		32	100	37	100

Table 8 shows the potential of the PBL-STEM learning model in improving students' scientific literacy. The experimental group using this model has a level of scientific literacy that is included in the Very High and High categories. In contrast to the control group that did not use the PBL-STEM model assisted by the Hinbiodiv application, the level of scientific literacy tended to be lower, with a distribution of scores in the categoryMedium and Low. The difference in results shows that the implementation of the PBL-STEM model assisted by the Hinbiodiv application is able to provide a positive impact on students' scientific literacy skills compared to conventional learning methods or lectures. In addition, it should be noted that the achievement of KKM 75 is not evenly distributed across all categories and groups.

Biodiversity material literacy is determined from individual completion and classical completion. Students' science literacy completion is presented in Table 9.

Table 9. Completion of Scientific Literacy of Experimental Group and Control Group Before and After Treatment

Completeness Science Literacy	Group Experiment		Group Control	
	Initial trials (%)	Post-test (%)	Initial trials (%)	Post-test (%)
Finished	number 0	76.47	number 0	51.35
Not completed	100	23.53	100	48.65
Total	100	100	100	100

Table 9 show a significant difference between the experimental class using the PBL-STEM model assisted by the Hinbiodiv application and the control class using the regular learning method or lecture. The classical completion of science literacy in the experimental class was recorded as higher than in the control class. Specifically, the percentage of students' science literacy scores in the experimental class reached 76.47% which is included in the high category, while the control class only reached 51.35% which is included in the moderate category.

These differences indicate that the PBL-STEM model assisted by the Hinbiodiv application has the potential to improve students' understanding and application of science concepts. Several studies in Indonesia that have been conducted have shown that STEM learning can improve scientific literacy, creativity, and problem-solving skills (Farwati, 2017; Permanasari, 2016). In addition, research conducted by Hapiziah (2015) stated that the learning outcomes of students who use STEM-Problem Based Learning-based teaching materials are greater than the learning outcomes of students who do not use these teaching materials. The learning process in the experimental class using the PBL-STEM model assisted by the Hinbiodiv application shows several advantages that need to be considered. The learning stages in this model are specifically designed to facilitate the development of students' scientific literacy indicators in the context of relevant problems. The use of the PBL-STEM model assisted by the Hinbiodiv application has proven effective in helping students understand biodiversity material that is associated with real problems. Nurkomaria et al. (2022) emphasize the importance of paying more attention to students so that STEM-based PBL learning is more active and interesting. The observation results showed that students in the experimental class tended to be more focused and actively involved in the learning process, especially when working on discussion sheets. Contextualization of learning through PBL-STEM assisted by the Hinbiodiv application helps students connect learning materials with real situations, thereby increasing the relevance and understanding of students' understanding of the science concepts being studied. In the journal Stohlman, et al. (2012) stated that the application of the STEM approach in education can motivate students to work together in developing science and mathematics skills with the aim of triggering students to be successful.

On the other hand, the control class using conventional or lecture learning methods showed some limitations due to the lack of facilities provided. Therefore, responses play an important role in student learning or development, therefore responses must be developed and controlled as well as possible (Suryabrata, 2014). The majority of students prefer to be quiet and listen to the teacher's explanation without giving further responses or questions. The conventional or lecture learning methods applied may be less able to stimulate active student involvement, which in turn can affect their level of understanding and application of science concepts. This difference becomes even more obvious when compared to the enthusiasm and involvement shown by students in the experimental class.

Improving Science Literacy in Experimental Groups and Control Groups

The increase students' scientific literacy can be calculated using pretest and posttest data with the formula in the N-gain test. The increase in scientific literacy are presented in Table 10.

Table 10. N-Gain Test of Scientific Literacy of the Experimental Group and the Control Group

Group	Improvement Literacy (%)			Average <g>	Criteria <g>
	Tall	At the moment	Low		
Test	88.24	2.94	8.82	0.79	High
Inspect	35.14	13.51	51.35	0.46	Moderate

The results of the N Gain analysis of students' scientific literacy showed that students' scientific literacy in the experimental class was 0.79 with high criteria, while the N-gain value of the control class was 0.46 with a moderate category. Thus, it can be concluded that Biology learning using the PBL-STEM model assisted by the Hinbiodiv application and regular learning can both improve scientific literacy, but in the experimental class the criteria obtained were higher than in the control class. This is because good mastery of concepts will produce learning outcomes, this difference still shows a positive influence from the application of the PBL-STEM model assisted by the Hinbiodiv application. The scientific literacy test was developed to achieve learning objectives (Imania & Bariah, 2019).

Science literacy also includes the ability to communicate scientific concepts clearly and effectively with. The importance of science literacy lies in the skills and understanding needed to make decisions based on facts and evidence, especially in matters related to health, the environment, technology, and public policy. With good science literacy, a person can understand how science affects their lives and society in general. The results of Sari et al. (2022) study showed that in STEM-based PBL learning, students are given activities to solve problems related to real life that are connected to science, technology, engineering, art, and mathematics so that students can solve the problems given. In line with the opinion of (Novita, et al. 2014) which states that the initial step in problem-based learning is to convey the problem, with the existence of the problem the concept of the problem will be discovered.

The results of the scientific literacy study are presented in Table 10. Based on Table 10, it was found that students' scientific literacy increased. In the experimental class, the highest increase occurred in the Reading and interpreting data indicator with an N-gain of 0.85 in the high category. In the control class, the highest increase occurred in the Understanding elements of research design and their impact on scientific discovery indicator with an N-gain of 0.36 in the medium category. This happened because the experimental class used STEM-based PBL Model learning facilitated by learning media in the form of the Hinbiodiv application. Student discussion sheets encouraged students to pay more attention during the learning process, but in the control class, the opposite was true. Problem Based Learning helps students' activities that focus on application, analysis and synthesis as well as analyzing problems and finding solutions, conducting evaluations with collaboration and presentations. The experimental class showed better improvement compared to the control class. The scientific literacy aspect obtained valid criteria so that the test used included aspects of content, context and indicators of scientific literacy in accordance with the PISA literacy test framework (Mentari Darma Putri, 2021). Then each question must use communicative language, effective sentences and sentence unity (Education, 2017). So that it is easy to understand, there are clear instructions on how to work on the questions and there are scoring guidelines Gimo & Nugrahani (2019) The following is an increase in the student's scientific literacy indicator which is determined based on the N-gain value presented in Table 11.

Table 11. Results of the N-Gain Analysis of the Science Literacy Indicator for Students in the Control Group and Experimental Group

No	Variables	N Advantage Class Control		N AdvantageClass Experiment	
			Criteria	Sign	Criteria
1.	Identifying appropriate scientific arguments	0.58	At the moment	0.83	Tall
2.	Use effective literature search	0.48	At the moment	0.82	Tall
3.	Evaluation in the use of scientific information	0.41	At the moment	0.77	Tall
4.	Understanding element design research and its impact on scientific discovery	0.36	At the moment	0.69	At the moment
5.	Create a graph that can represent data	0.45	At the moment	0.76	Tall
6.	Reading and interpreting data	0.47	At the moment	0.85	Tall
7.	Problems with probability solutions	0.52	At the moment	0.83	Tall
8.	Understand and be able to interpret basic statistics	0.47	At the moment	0.80	Tall
9.	Presenting conclusions	0.44	At the moment	0.79	Tall
Average		0.46	At the moment	0.79	Tall

Table 11 shows that the reading and interpreting data indicators are the highest indicators in the experimental and control classes, but there are significant differences between the experimental and control classes because educators design learning that explicitly uses the PBL-STEM model assisted by the Hinbiodiv application by integrating the development of scientific literacy. Nugrahaeny (2015) stated that through the application of the Problem Based Learning learning model, students will understand science material and improve cooperation. In STEM classes, students are required to solve real-world problems and engage in ill-defined tasks to become well-defined outcomes through group collaboration (Han, Capraro, & Capraro, 2015). This can involve the use of inquiry-based projects, collaborative learning, and technology integration in science learning.

In the indicator of understanding the elements of research design and its impact on scientific discovery, it is the lowest indicator in both the experimental and control classes because students in the experimental and control classes are not used to conducting research and it is something new so that students are still adapting to the questions given. However, in the experimental class it is already in the moderate category and the N-Gain value is significantly different from the control class. This is because in the experimental class, learning uses the STEM-based PBL Model. This is supported by (Yasini & Suryaman, 2019) that teaching materials encourage learning to be more student-centered so as to reduce dependence on teachers with the help of the Hinbiodiv application, students feel curious about more when participating in learning because with the discussion sheet students are interested in finding out and understanding the problems given in order to solve them, this is in line with research by Alfiana & Iswari, (2022) that teaching materials that are presented comprehensively and equipped with pictures can prevent students from misunderstanding the material and improve students' thinking skills. In line with research conducted by Novellia (2018) which states that the application of the PBL model can improve students' creative thinking skills.

The research results of Nurkomaria et al. (2022) show that paying more attention to students will make STEM-based PBL learning more active. Through STEM learning, students have knowledge of science and technology literacy which is evident from reading, writing, observing, and doing science in the environment (Mayasari et al., 2014), In addition, this model is identified as suitable for improving learning outcomes and student activities (Mayawati et al., 2020; Nasoha et al., 2022; Nasution & Alzaber, 2020; Nurkomaria et al., 2022). In STEM-based PBL learning, students feel that what the teacher conveys can be material or a source of knowledge in solving conservation problems, Syukri (2020).

Thus, the difference in the increase in students' science literacy indicators in the experimental class is better than the control class due to differences in the learning process. This generation is able to think and behave scientifically by applying science literacy directly (Linder et al., 2014). Therefore, science literacy skills must continue to be trained and accustomed to in the world of education. The implementation of STEM-based learning requires a change in the learning model from teacher-centered learning to student-centered learning, as well as individual learning to collaborative learning and emphasizes creativity and problem solving in the application of scientific knowledge. Some of the benefits of the STEM approach make students able to solve problems better, be innovative, independent, think logically, and be technologically literate (Morisson, 2006).

CONCLUSION

The implementation of the PBL-STEM Model assisted by the Hinbiodiv application can improve students' scientific literacy in the experimental class with a high category N-Gain value, while for the control class with the usual learning method or lectures the N-Gain value is in the medium category. The reading and interpreting data indicators are the highest indicators in the experimental and control classes, so it can be concluded that the implementation of the PBL-STEM Model assisted by the Hinbiodiv application is recommended for use in biology learning in high school to improve scientific literacy.

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