EFFECTIVENESS OF WETLAND-BASED WAVE AND OPTICS MODULES ON STUDENTS' SCIENTIFIC LITERACY ABILITIES

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Abstract
Wetlands that dominate the area in South Kalimantan are one of the indigenous science learning resources that can help students learn. However, the insertion of wetlands has not commonly been done on a learning media which directly used in class. The developed wetlands-based module on wave and optics aimed to enhance students’ scientific literacy which leads to the success of learning by integrating indigenous science. It was implemented for thirty science education students by using a group pretest-posttest design. The results showed that 29 students gained increased scientific literacy during the implementation, with the improvement in each aspect of scientific literacy categorized as moderate. In addition, the Wilcoxon test result showed a significant enhancement of scientific literacy after using the wetlands-based module of wave and optics. Thus, the wetland-based module is effective in improving students’ scientific literacy abilities.

Keywords: Scientific Literacy, Wave and Optics, Wetlands

INTRODUCTION
Based on the latest lecture administration regulations, lecturers are expected to apply case-based learning methods and/or team-based projects. This method should be integrated with the university's flagship, namely the wetland environment so that the institution's vision and mission are achieved. However, the insertion of the wetland environment elements in learning is still rarely done (Aufa et al., 2021), especially in Waves and Optics courses, whereas Kiswanto (2022) stated that the environment is an essential thing in science learning as it should be the source of learning. The insertion can be done in various ways, one of which is through learning material, such as module (Arfiani & Kusuma, 2019). However, until now there are still several courses that do not have modules that are based on the wetland environment and implemented with a case-based method and/or team-based project methods so the application of the methods is not optimal. This study developed a module with case-based method which
required students to think critically and scientifically (Candra et al., 2023).

The wetland environment is a characteristic of the land dominating the South Kalimantan region (Nugraha et al., 2022). As students who were born and grew up in a wetland environment, the integration of a wetland environment in learning can be used as a science learning resource because it can help students understand the material and the environment (Aini et al., 2018). Anissa et al. (2021) also support this by stating that incorporating the existing potential in the surrounding area into learning can train critical thinking, analytical, and problem-solving abilities. Nofiana & Julianto (2018) argued that learning based on local flagship can increase students’ scientific literacy because they can relate material and directly experience the phenomena they are learning.

Scientific literacy is essential for students as they will deal with real-life problems (Istiqomah et al., 2023) in the future regarding the environment and changes as an effect of human activities, thus they need this ability to find solution resolving those issues (Purnomo et al., 2023). The importance of increasing scientific literacy is also based on data from the Programme for International Students Assessment (PISA) (OECD, 2019) which explains that Indonesia was in 64th place out of 75 countries studied in 2015 (Kristyowati & Purwanto, 2019). Most recently (in 2018), Indonesia was ranked 69th out of 79 countries with an average score in three areas of scientific literacy which has decreased from the previous year (2015) as shown in Figure 1.

![Figure 1. Indonesian students' performance of scientific literacy (OECD, 2019).](image-url)
The data shows that the performance of students' scientific literacy in Indonesia has decreased, especially from 2015 to 2018, even though the changes were quite volatile. This is because science learning in Indonesia is still lacking in integrating scientific literacy (Rusmansyah et al., 2023); (Kelana & Pratama, 2019). Therefore, it is necessary to increase scientific literacy for students in Indonesia so that they can compete globally (Fakhriyah et al., 2019).

**METHODS**

This study is a quasi-experimental research with one group pretest-posttest design in which the evaluation was done before and after a treatment on one group (Romano et al., 2023). The sample used in this study was 30 science education students taking Wave and Optics courses with a total population of 81 students. Samples were taken using a simple random sampling technique because all members of the population have homogeneous initial abilities in wave and optics topics based on the preliminary test so they have equal chance to be the sample of this study (Mishra & Alok, 2017). The data collection technique used pretest and posttest questions to measure the increase in scientific literacy abilities as a representation of the effectiveness of the module (Rahmiati et al., 2023). This assumption was taken based on logical reasoning that if students experienced an increase in scientific literacy abilities after using the module, then the module can be said to be effectively used to train scientific literacy abilities. The data analysis technique was quantitative descriptive to analyze each aspect of scientific literacy and n-gain analysis to see the increase in students' initial and final abilities (Sesmiyanti et al., 2019). If the n-gain score is positive, then there is an increase of students’ abilities (Nurwita et al., 2023); and the n-gain score shows the criteria of effectiveness as shown in Table 1.

<table>
<thead>
<tr>
<th>Gain Score</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>g &gt; 0.7</td>
<td>High</td>
</tr>
<tr>
<td>0.3 &lt; g &lt; 0.7</td>
<td>Moderate</td>
</tr>
<tr>
<td>g ≤ 0.3</td>
<td>Low</td>
</tr>
</tbody>
</table>

Furthermore, the data hypothesis test was carried out using the Wilcoxon test to determine the effectiveness of using the wetland-based Wave and Optics module on scientific literacy abilities. This test was chosen because the research data were not normally distributed and not homogenic based on the prerequisite test (Setiawan et al., 2020).

**RESULTS AND DISCUSSION**

The results of the n-gain analysis on students' scientific literacy abilities before and after using the wetland-based Wave and Optics module are shown in Table 2.

<table>
<thead>
<tr>
<th>Table 1. Gain score index criteria</th>
</tr>
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<tbody>
<tr>
<td>Gain Score</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
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</tr>
<tr>
<td>g ≤ 0.3</td>
</tr>
</tbody>
</table>

Table 2. Result of n-gain analysis.
From Table 2, it is explained that out of 30 students, there was only one student who did not experience an increase in scientific literacy abilities, or there was no change (the score was equal). On the other hand, 29 other students experienced an increase in scientific literacy abilities which was marked by individually higher posttest scores than pretest scores. The scientific literacy as measured in this study was based on aspects of scientific literacy as measured in PISA, which includes three aspects (Nurhayati et al., 2023), namely (1) identifying scientific issues, (2) explaining scientific phenomena, and (3) using scientific evidence, where the results of the analysis on each aspect are shown in Table 3.

Table 3. Analysis of scientific literacy ability in each aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Pretest Score</th>
<th>Posttest Score</th>
<th>N-gain</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying scientific issues</td>
<td>35.50</td>
<td>80.50</td>
<td>0.47</td>
<td>Moderate</td>
</tr>
<tr>
<td>Explaining scientific phenomena</td>
<td>43.67</td>
<td>87.00</td>
<td>0.56</td>
<td>Moderate</td>
</tr>
<tr>
<td>Using scientific evidence</td>
<td>33.00</td>
<td>85.25</td>
<td>0.60</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Table 3 shown that the three aspects of scientific literacy have experienced a moderate increase (0.30<g<0.70). However, in the aspect of identifying scientific issues, the n-gain score obtained is the least increasing, as well as the average score in this aspect, is the lowest. Then, the aspect with the highest final score is the ‘explaining scientific phenomena’. This aspect leads to the ability to model any abstract scientific phenomena to decrease the difficulty in science learning (Winkelmann, 2023). The increase in scientific literacy abilities in the aspect of using scientific evidence is the most significant because it increases by 60%. Therefore, the aspect of identifying scientific issues still needs to be improved, without neglecting other aspects.

Identifying scientific issues is the most basic aspect but also a quite complex one (Sa’diyah, 2023) because students are expected to be able to answer a question based on scientific reasoning (Rini et al., 2021), whereas in this section students must be able to identify variables in the proposed case that are relevant to the topic being taught. Even though it is included in the moderate criteria, the n-gain score on this aspect is the lowest. This is
because students find many difficulties in this section caused by the lack of students' ability to relate the material to the surrounding environment (Mulyani et al., 2020). It is also supported by Rahmawati et al. (2020), in their research it was explained that only 50% of students were able to relate science knowledge in everyday life well, while the other 50% were classified as moderate to not very good at understanding the context of science in everyday life. This shows that students in Indonesia, especially in science learning, have not been trained well in this regard. This ability needs to be trained, not only on the concepts of Wave and Optics but also on other science concepts so that students' ability to identify problems can be enhanced (Campbell & Howitt, 2023). It is expected that if the problem identification aspect can be carried out well, then other aspects such as explaining scientific phenomena and providing scientific evidence can also be carried out properly so that students' scientific literacy abilities develop (Russell & Martin, 2023).

![Figure 2. Chart of increasing scientific literacy per aspect](image)

On the other hand, the improvement in the ability of each aspect seen in Figure 2 shows that each aspect has changes that are not much different, which means that overall the Wetland-based Wave and Optics module which is implemented using the case-based method has an impact on the scientific literacy of the students. As a reference, research by

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After it was proven that this module increased students' scientific literacy reviewed from the n-gain scores, the Wilcoxon test was carried out to ensure that there was a significant difference between students' initial and final abilities after using this module. The results of the Wilcoxon test can be seen in Table 4.

<table>
<thead>
<tr>
<th>Test Statistics</th>
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| Z               | -4.704^b  
| Asymp. Sig. (2-tailed) | .000  

a. Wilcoxon Signed Ranks Test  
b. Based on negative ranks.

From Table 4, the use of this module is proven to increase students' scientific literacy abilities in traveling wave and sound wave topics, with a significance of 0.00 (<.05) (Orlhac et al., 2021), which means that there is a significant difference between pretest and post-test scores, or between initial and final scientific literacy abilities after using the module. These results show a comparison between scientific literacy scores before and after using the module, but cannot yet present how much influence the use of the wetland-based module with this case-based method has on increasing scientific literacy. This is because in this study there has not been an evaluation of the use of the module specifically, only the effectiveness of the module from a student's cognitive perspective so the variable use of the module cannot be correlated with the increasing students' scientific literacy.

CONCLUSION AND RECOMMENDATION
The wetland-based Wave and Optics module with case-based method has moderate effectiveness for use in Wave and Optics course, especially for travelling waves and sound waves topic. Also, the use of this module is significant in improving students' scientific literacy abilities (sig<0.05).

Suggestions for researchers with similar topics, learning media should be developed more towards integrating the wetland environment as a whole, not only using this element as a case basis, so that science learning can achieve complete and meaningful learning.

REFERENCES
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