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PAPER

Developing Students' Scientific Literacy through Wikipedia Digital Library

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ABSTRACT

This study investigates the impact of utilizing the digital library Wikipedia on high school students' scientific literacy skills in biology. This research used a quasi-experiment design with a one-group pre-test and post-test method, conducted in a high school in Bandung, Indonesia. The participants consisted of 60 tenth-grade students. The research instrument consisted of 24 multiple-choice questions designed to assess nine scientific literacy indicators, including the ability to describe phenomena scientifically, design and evaluate scientific investigations, and interpret data and evidence scientifically. Each question was scored dichotomously, with the correct answer receiving a score of 1 and incorrect answers assigned a score of 0. Pre-test and post-test scores were analyzed using the Rasch model through Winsteps Version 3.73. Based on data analysis, the items fit with the Rasch model because the infit and outfit MNSQ is 1.0 and the residual item of unexplained variance is 2.3% to 9.8%. The reliability of the items shows an item value of 0.97, which is classified as excellent. The indicators considered the most difficult before being treated were identifying accurate scientific ideas, distinguishing between types of sources, and evaluating literature source validity after the treatment. There was a significant improvement in students' scientific literacy skills after utilizing the digital library, Wikipedia. The findings provide valuable insights into the effectiveness of integrating digital media into biology courses, highlighting the potential of Wikipedia as a digital reference source for enhancing students' scientific literacy in high school settings.

KEYWORDS

scientific literacy, digital library, Rasch model, Wikipedia, biology education

1 INTRODUCTION

In the current digital era, technology-based digital media and the Internet play a vital role in supporting scientific education. Technology provides students with quick and easy access to various information [1]. Among the digital resources available, Wikipedia stands out as a widely used source of information for scientific studies. That's because Wikipedia is the largest and most free encyclopedic knowledge

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source. Wikipedia is among the most visited websites worldwide [2], after Google, YouTube, Facebook, Twitter, Instagram, and Baidu. The popularity of Wikipedia is due to the completeness of its topics, both in social and scientific aspects. Information spreading from Wikipedia also increases on various issues through free content [3]. The platform features explicit, novel content and easy-to-understand information [4]. Wikipedia is a benchmark for finding popular information in internet-based digital media [18–19]. Wikipedia is increasingly being used and attracts millions of visitors of all ages, cultures, and backgrounds globally because it is available in 325 language variations and has an attractive appearance with images and graphics. Wikipedia, as a digital reference, continues today.

In education, Wikipedia was a digital reference source based on Internet technology [7], [8]. Wikipedia is widely used in learning activities. Initially, many doubted the quality of Wikipedia's content and allegations of misinformation, so several institutions prohibited teachers and students from using Wikipedia [7], [9], [10]. However, this assumption is gradually changing because Wikipedia is supported by millions of editors and moderators of multi-sourced content [11], [12]. This research focuses on whether the digital library Wikipedia usage in biology learning contributes to improving students' scientific literacy to support biology learning with innovative digital media that has not been used previously.

Based on these opinions, it can be concluded that scientific literacy is students' skill in apprehending concepts, writing, verbalizing, and using scientific understanding to solve situations in daily life so they can make the correct findings based on scientific considerations. Moreover, students must adapt to current technological developments. One of the best solutions is to use the Wikipedia digital library. The skills assessment result can be applied to the Rasch model developed by George Rasch. The Rasch model was suitable for measuring latent properties in assessing human insight and attitudes [13–15]. This research aims to investigate the impact of utilizing the digital library Wikipedia in biology learning on students' scientific literacy skills. By conducting this research, valuable insights can be gained regarding the effectiveness of using Wikipedia as a digital reference source in biology education, thus contributing to the broader understanding of innovative digital media utilization in classroom settings and its impact on students' scientific literacy skills.

2 METHOD

This research used the quasi-experiment method with one group pre- and post-test. This design is a type of quasi-experiment in which the outcome of interest is measured twice: once before and once after exposing a non-random group of participants to a certain intervention. The treatment group used the digital library Wikipedia to learn biology. They used the digital library Wikipedia to guide their teaching and learning sessions. Students are due to carry out the task and activity sheets containing science context in biology for eight meetings. The subject of this research is 60 students of grade X high school in Bandung.

This research used item responses from the TOSLS test according to Gormarlly [16], then modified and tested. The instrument consisted of 24 multiple-choice questions with nine scientific literacy indicators to be assessed. The indicators are presented in Table 1. Scores were obtained from tests before and after treatment—pre- and post-test. Both data were analyzed simultaneously using Winsteps Version 3.73 with dichotomous analysis using the Rasch model [17].

Table 1. Indicators of scientific literacy assessment in biology subject matter and test' codes

Indicators	Partial Indicators	Test Label (Pre Test)	Test Label (Post Test)
Describing the phenomenon scientifically	Identifying accurate scientific ideas (e.g., opinions/ theories to support hypotheses)	A1, A2, A3	A-1, A-2, A-3
	Distinguishing between types of sources and evaluating literature source validity	A4, A5, A6	A-4, A-5, A-6
	Understand the parts in investigation design	A7, A8, A9	A-7, A-8, A-9
	Examining data accurately	A10, A11, A12	A-10, A-11, A-12
Designing and evaluating scientific investigation	Solving issues using quantitative skills, including basic statistics (e.g., estimating average, probability, ratio, frequency)	B1, B2, B3	B-1, B-2, B-3
	Understanding and interpreting the outcomes of statistical calculation	B4, B5, B6	B-4, B-5, B-6
Interpreting data and proof scientifically	Sketching inferences and creating predictions based on quantitative data	C1, C2, C3	C-1, C-2, C-3
	Assessing scientific information	C4, C5, C6	C-4, C-5, C-6

3 RESULT AND DISCUSSION

3.1 The scientific literacy skills item test resume

The results showed that the 24 questions developed were valid based on expert judgment by three biology education experts. We apply the Rasch analysis partial credit model because it allows estimation of the step difficulty in each item. Infit and outfit MNSQ were used to ensure data-model fit. Table 2 shows the average infit and outfit MNSQ is 1.0 (Figure 1). Other data shows that the residual item of unexplained variance is 2.3 to 9.8%.

Table 2. Overview of item

	Total Score	Count	Measure	Model Error	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
Mean	29.2	58.1	0.0	0.6	1.0	0.1	1.0	0.2
S.D	24.6	2.9	3.7	0.2	0.1	0.4	1.5	1.3
Max	59.0	60.0	4.5	1.0	1.3	1.1	9.9	7.6
Min	2.0	49.0	–4.8	0.3	0.6	–1.0	0.1	–1.0
REAL RMSE	68.00		True SD	3.58	Separation	5.27	Reliability	0.97
MODEL RMSE	0.67		True SD	3.58	Separation	5.37	Reliability	0.97

The construct validity of the test was confirmed when the items matched the assumptions of the unidimensional Rasch model because, in this study, 1) the infit and outfit mean square ranged, and 2) the variance explained was smaller than 20%; the test was considered unidimensional [18].

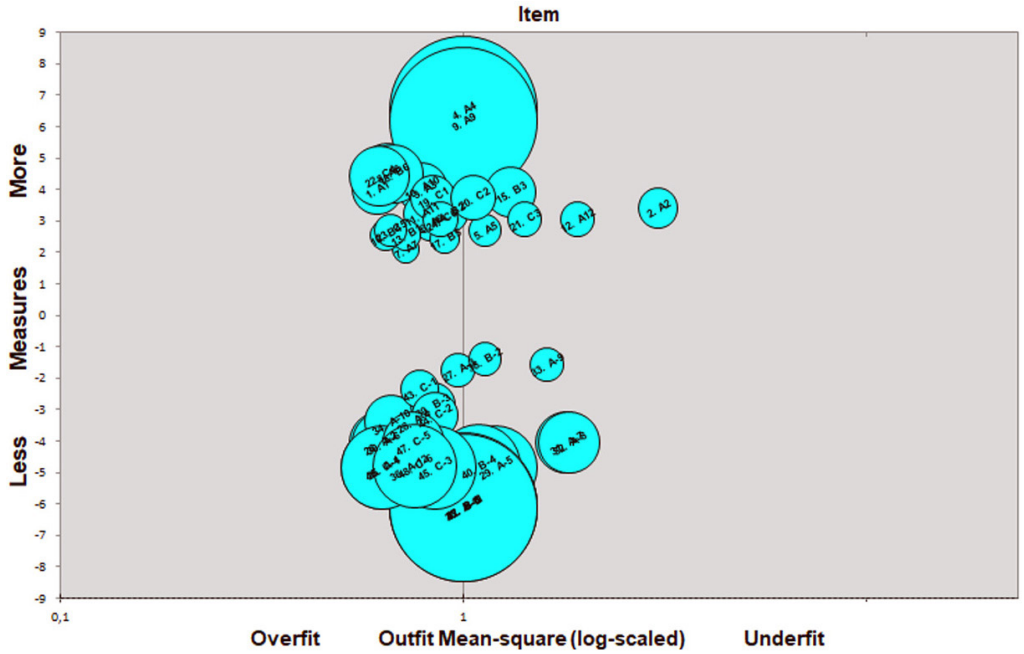

Fig. 1. Bubble outfit mean-square item test of scientific literacy pre- and post-test

3.2 Wright's map item test of scientific literacy

Wright's map analysis focuses on the difficulty of the questions. The higher the item's position, the higher the difficulty; the lower the item's position, the easier the question. Item measure analysis is used to see the difficulty level of the questions [19]. Classification of the level of questions' difficulty according to the criteria of very difficult (> 6.00 logit), difficult (2.0–5.0 logit), easy (–2.00 – 0.00 logit), and very easy (< –2.00 logit) (Figure 2).

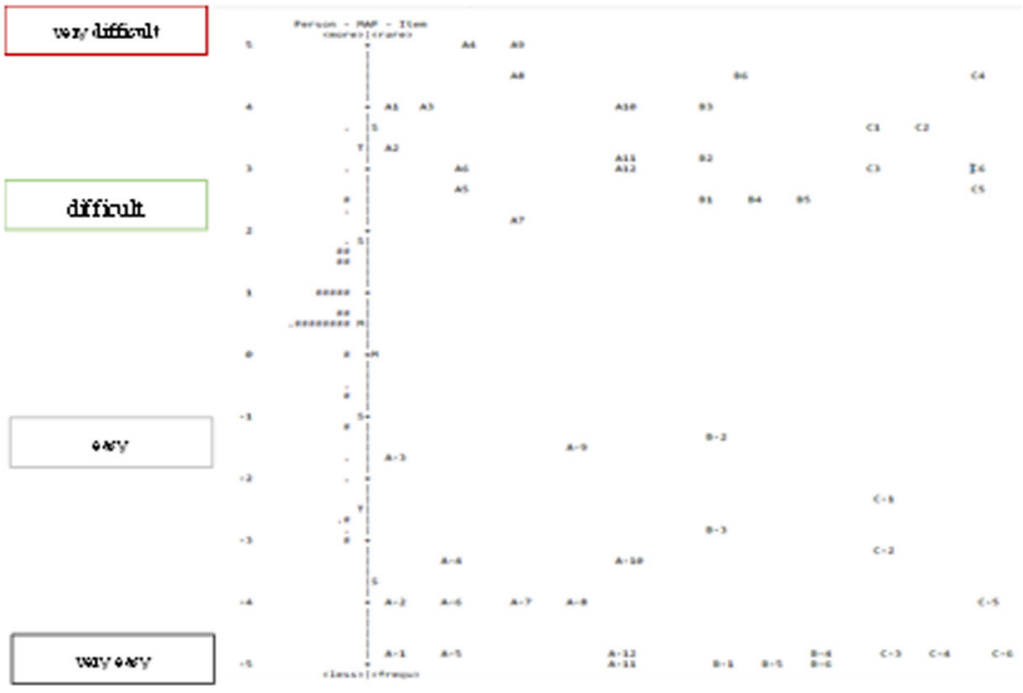

Fig. 2. Wright's map item test of scientific literacy pre- and post-test

3.3 Changes in students' scientific literacy skills in each indicator

Describing the phenomenon scientifically. At this stage, students are asked to describe the phenomenon scientifically using the Wikipedia digital library. The test results before and after the treatment are shown in Figure 3. Figure 3 shows the changes in student activities that were considered very difficult before biology learning using the Wikipedia digital library. The changes are less significant, which became easier after learning activities with the help of the Wikipedia digital library as an information source, including activities in understanding the parts of investigation design (A9). Less significant changes indicate that using the Wikipedia digital library has little effect on students understanding of elements of research design. This activity requires in-depth analysis in designing the investigation process for the given problem. So, besides a complete reference through the Wikipedia digital library, students also have to do more research and have high reasoning skills [14].

The following finding from Figure 3 is that students felt very difficult before learning, and there was a very significant change (very easy) by utilizing the Wikipedia digital library. These findings are for some aspects: student activities in distinguishing between types of sources (A4) and evaluating literature sources and examining validity data accurately (A11). These findings prove that using the Wikipedia digital library has an excellent effect on improving students' scientific literacy skills. This is because of the Wikipedia digital library's role as a reliable reference source in many learning activities, such as searching for information and building knowledge [20]. It can be concluded that using the Wikipedia digital library properly can serve as a model for enhancing 21st-century skills and literacy toward new technologies in the future.

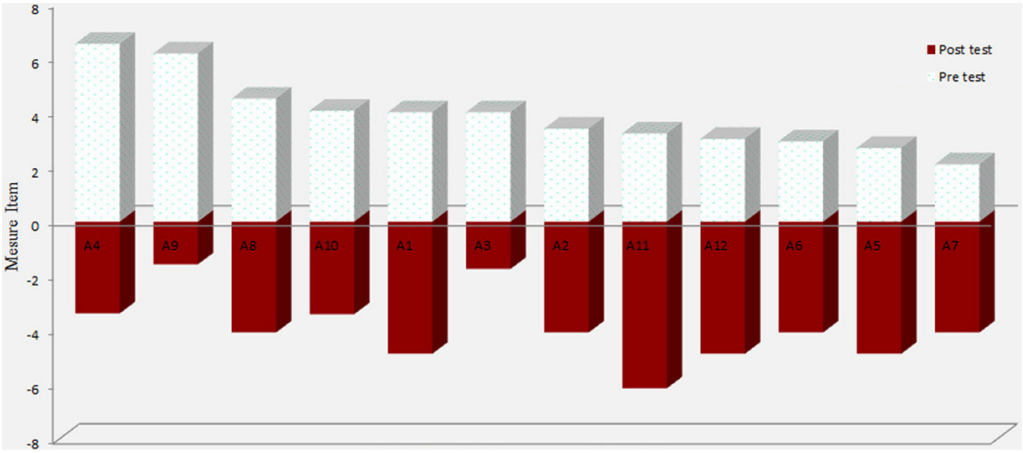

Fig. 3. Transformations in students' scientific literacy skills in describing the phenomenon scientifically

Designing and evaluating scientific investigation. At this stage, students are asked to design and evaluate a scientific investigation using the Wikipedia digital library. The measuring results of scientific literacy skills before and after treatment are shown in Figure 4. Figure 4 shows the less significant changes that occurred in student activities. Students considered learning activities very difficult before using the Wikipedia digital library, and changes became easier after learning to use the Wikipedia digital library as a source of information, including student activities in solving issues using quantitative skills, including basic statistics (B2, B3).

These findings indicate that, besides serving as a reference source, the Wikipedia digital library can help students master skills in basic numeracy and statistics, which are needed to implement in the problem-solving process. It can be concluded that Wikipedia digital library still requires supervision from the teacher. Because without a teacher as a facilitator, the Wikipedia digital library will not be optimally used as a reference by students in seeking scientific information [21].

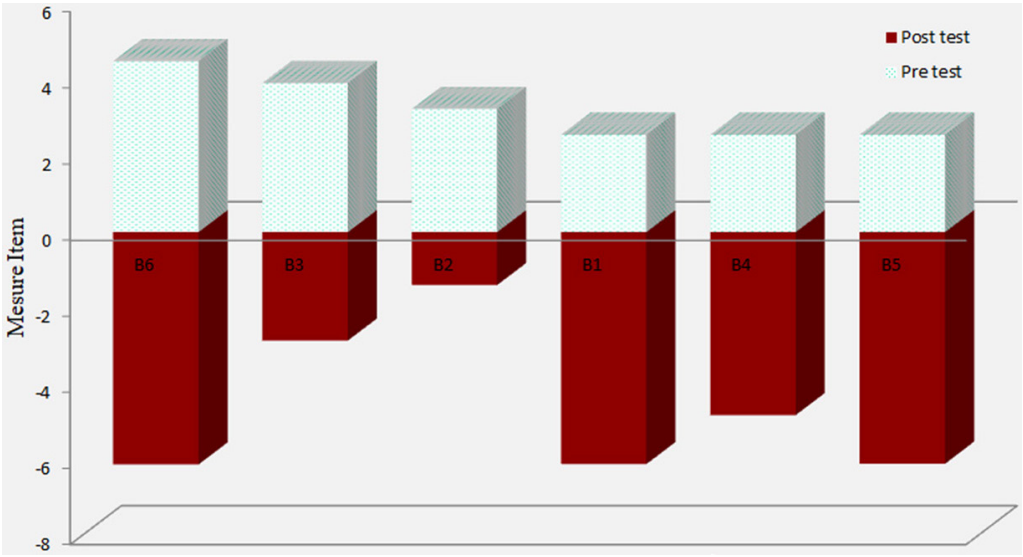

Fig. 4. Transformations in students' scientific literacy skills in designing and evaluating scientific investigation

The next finding from Figure 4 is a significant change between before and after treatment in students' scientific literacy skills. Students felt it was very difficult before learning. After learning activities using the Wikipedia digital library, there was a significant change (very easy), including student activities in understanding and interpreting the outcomes of statistical calculations (B4, B5, B6). These findings reinforce that the Wikipedia digital library helps students understand literature containing statistical data such as graphics [2], [22]. Information in the form of graphs or statistical data available on the Wikipedia digital library provides opportunities for students to practice understanding and interpreting the outcomes of statistical calculations. These activities support efforts to improve students' scientific literacy skills.

Interpreting data and proof scientifically. At this stage, students are asked to interpret data and proof scientifically with the help of the Wikipedia digital library. The measuring results of scientific literacy skills before and after treatment are shown in Figure 5. Figure 5 shows the less significant changes that occurred in student activities. Students considered learning activities very difficult before using the Wikipedia digital library, and changes became easier after learning to use the Wikipedia digital library as a source of information, including student activities in sketching inferences and creating predictions based on quantitative data (C1). These findings indicate that other skills are also needed to improve students' scientific literacy skills, including critical thinking, especially if it is based on numerical data. So it can be concluded that Wikipedia digital library support still needs to be provided with other skills for students to solve environmental problems closely related to scientific concepts.

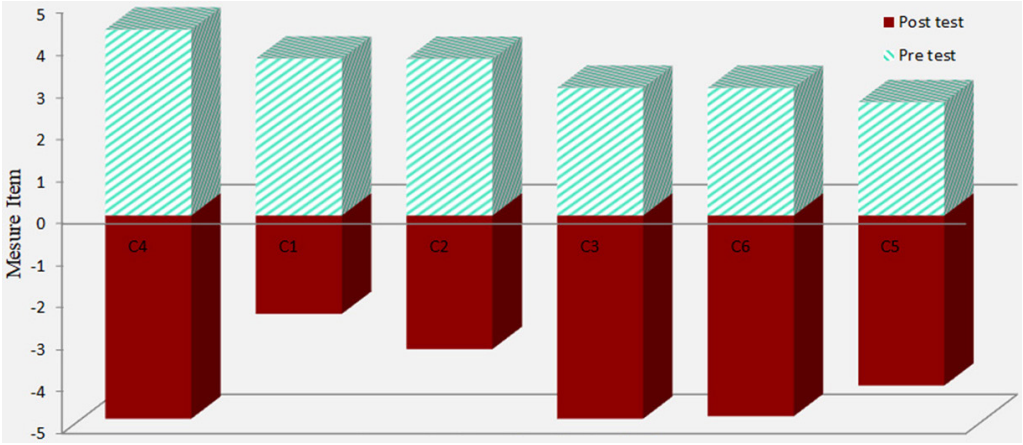

Fig. 5. Transformations in students' scientific literacy skills in interpreting data and proof scientifically

The next finding from Figure 5 indicates that using the Wikipedia digital library optimally supports students' ability to understand and evaluate scientific information from the learning activities. These findings align with many opinions, stating that scientific literacy skills increase along with the large amount of digital information.

4 CONCLUSION

Learning activities for senior high school grade 10 students in biology subject using the Wikipedia digital library have been shown to improve students' scientific literacy skills. Changes in skills before and after learning activities can be seen from changes in the difficulty level of the questions. Changes in the difficulty level that get easier after learning activities show that students are more able to work on questions that measure their scientific literacy skills. Each question represents an indicator of scientific literacy skills, which means there is a change in students' scientific literacy skills after the biology learning activity with the help of the Wikipedia digital library.

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