MEASURING MIDWIFERY UNDERGRADUATE SCIENTIFIC LITERACY AND REASONING: SCIENTIFIC WRITING ON MICROBIOLOGY

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ABSTRACT

Students are encouraged to use critical thinking skills in their current coursework to solve case studies. Students can express their critical thinking through written communication. Scientific writing demonstrates students' logical reasoning and comprehension of a problem. Proficiency in scientific writing is essential for midwifery students who wish to disseminate best practices or pursue their careers as lecturers or researchers. However, scientific writing is common for students who completing their final projects. In this paper, we assessed first-year undergraduate scientific literacy and argumentation on microbiology. We assessed students' scientific writing using a rubrics. Based on rubrics criteria, students' critical thinking skills demonstrated their ability to examine data, but their skills in problem identification and data transformation remain limited.

Keywords**:** scientific writing, scientific literacy, arguments, rubrics

A. INTRODUCTION

Science learning in higher education gives opportunities to build skills aligned with the graduate profile's objectives. Written and spoken communication, teamwork, time management, and problem-solving are skills required for job mastery (Stephenson & Sadler-Mcknight, 2016). Learning in the 21st century encourages students to use critical thinking when solving problems. Scientific writing can be used to channel students' critical thinking skills.

Scientific writing is a type of written communication that describes students' logical reasoning and comprehension of a problem (Dowd et al., 2018). Scientific writing can help students build scientific thinking, which is a critical thinking process that can explain patterns and relationships in a case, solve a problem, and reach decisions and conclusions. Scientific writing skills can help to integrate interdisciplinary knowledge and generate complete understanding (Gvili et al., 2016). This can describe how an individual thinks about identifying problems, devising solutions, and drawing conclusions.

Scientific writing abilities are essential in the age of information overload on the internet, therefore critical thinking skills are required when processing material in a scientific setting (Holincheck et al., 2022). This written scientific communication can demonstrate how researchers can provide reliable information on social media to impact users' information processing and attitude development (Cabreja-Castillo et al., 2023; Howell & Brossard, 2021). These two factors are closely related to scientific literacy: the individual's ability to understand science as knowledge, the ability to use scientific concepts, the efficacy of using scientific processes, and the readiness to develop science and technology-based skills (Showalter,1974; Li & Guo, 2021).

According to Norris and Philips (2003), scientific literacy includes an understanding of scientific information as well as the ability to apply scientific principles in everyday life. Scientific literacy also includes the ability to think critically about science and deal with scientific competence. Scientific literacy abilities are critical in preparing individuals to function in society by empowering them to reason, detect problems, and make responsible decisions (Holbrook & Rannikmae, 2009).

An individual's scientific literacy can be expressed in his way of thinking, which is articulated in scientific literature. Scientific writing plays an important role in higher education because it helps students acquire critical thinking abilities that will be valuable when they start working and become members of society (Erkol et al., 2010). Scientific writing abilities are also required for midwifery students because their degrees deal with specific difficulties that necessitate critical thinking in decision-making. Furthermore, scientific writing abilities are necessary for them to communicate best practices or future research. In this sense, scientific writing abilities can enable students to think critically when developing a thorough understanding; (Sezen & Bülbül, 2011; Dowd et al., 2018).

The purpose of scientific writing on microbiology is to assess midwifery students' critical thinking skills in scientific texts on microbiology issues. This is significant since midwifery students work in the field of public health, which necessitates clean and sterile environments to safeguard the environment from pathogens. Students are taught to perform analysis by thinking critically when conducting studies and generating conclusions from a topic through the use of scientific writing.

B. RESEARCH METHOD

Participant and course description

The participants are a convenience sample (n=39) enrolled in a campus-based course entitled Microbiology for midwifery undergraduates. The course introduced basic theory of microbiology and public health microbiology. Course learning outcomes listed that students will be able to: 1) identify and characterize bacteriology, virology, mycology, 2) identify infectious diseases caused by microbiology, 3) understanding of infection prevention and control. In addition to enhance students' scientific literacy and reasoning, we develop an understanding of public health microbiology cases by literature review. Students discussed the given case in groups.

Scientific writing on microbiology

Scientific writing was a part of the course to capture students' scientific literacy and their reasoning to acknowledge public health microbiology case. We chose an article of soil transmitted-helminths (STH) infection case in children based on Rosyidah & Prasetyo (2018) study. We only use the article result as a topic for students' writing. Based on the given result, students construct scientific logical thinking to explain the result. Scientific logical thinking discussed in this work were students' critical thinking on information processing and data analyzing. We defined information processing as the way student assimilate data and then transform it into new form. Data analyzing include the way student examine the data and then generate conclusion based on data. From the given topic, students are asked to determine the problem, combine information from different sources, analyze the data, and generate conclusion are part of students critical thinking skills (Reynders et al., 2020).

We use critical thinking rubric as a tool to measure students' scientific literacy. The rubrics were adapted from Reynders (Reynders et al., 2020) and Gormally (Gormally et al., 2012) (Table 1). The rubric has five categories which interpreted according to a 3-level evaluation system (Horanska et al., 2022):

- high level (score= 3) — the student correctly and accurately assessed the information as a whole
- medium level (score=2) — the student has some errors and partially accurate when assessed the information
- low level (score =1) — the student has minimally and inaccurate when assessed the information

Critical thinking on information processing in the categories include evaluating, interpreting, and transforming; critical thinking on data analyzing include analyzing and synthesizing.

Table 1. Critical Thinking Rubrics

Category	3	2	1
Evaluating	Recognize scientific problems or arguments accurately	Partially accurate recognize scientific problems or arguments	Inaccurate recognize scientific problems or arguments
Interpreting	Recognize variables and determine problem-solving design based on data accurately	Partially accurately recognize variables and determine problem-solving design based on data	Inaccurate recognize variables and determine problem-solving design based on data
Transforming	Identify and converted graphical representation accurately	Identify and converted graphical representation with some errors	Inaccurate identify and converted graphical representation
Analyzing	Accurately analyze data to find meaning and create relevant evidence	Partially accurate analyze data to find meaning and create relevant evidence	Inaccurate analyze data to find meaning
Synthesizing	Accurately generate conclusion by integrating the data	Partially accurate generate conclusion by integrating the data	Inaccurate generate conclusion

C. RESULTS AND DISCUSSION

Midwifery students' scientific literacy is demonstrated by scientific writing on the subject of microbiology. Students are first-year students, but they comprehend the microbiology concerns in the given scenario. Students' scientific writing demonstrates scientific literacy through data processing and critical thinking skills. The categories evaluating, interpreting, and transforming as data processing skills, whereas the categories analyzing and synthesizing as critical thinking skills.

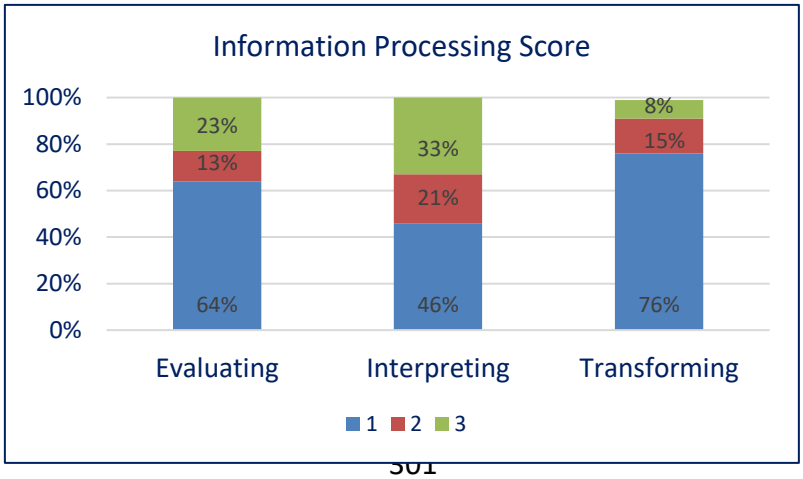

Figure 1. Students rubric score from information processing skills

Evaluating

A total of 23% of students had relevant issues when it came to data processing. Students who receive a score of 3 can state the challenges in developing an effective problem formulation. This student has correctly assessed the situation; they can analyze the fragments in a certain order:

> *"Soil-transmitted helminth infections are common in children who engage in soil-based sports such as football or field activities. This is the source of the problem with soil-transmitted helminth illnesses in children, which must be avoided thus personal hygiene habits are required. The challenge posed in this study is "How to maintain sanitation to prevent soil-transmitted helminths (STH) infections in children?"*

Students can demonstrate the independent variable as personal hygiene habits, and the dependent variable as STH infections in children. Students can state that more effort is required to prevent STH infections. This is consistent with the evidence presented in the form of the association between risk factors and worm infections in the form of the state of the defecation region, cleaning hands after defecating, playing with the soil with your hands, and washing your hands after playing with the soil.

Students who can partially perceive scientific problems or reasoning can find problems, but the problems they expose are not related to the problem formulation they proposed (score of 2). Students answer can detect issues caused by STH infections, but they do not incorporate the problems into the problem formulations they develop. The report stated:

> *"According to the findings, STH infections can disrupt digestion and limit nutrient absorption and immunological response. How does hand-washing affect STH infections?"*

Students who received a score of 1 (64% of students) indicated that they incorrectly identified scientific difficulties or arguments. The background of the problem and the proposed solution are not continuous.

Interpreting

In scientific writing on microbiology, interpretation skills take the shape of identifying research design features. As many as 33% of students can determine the research design using the information that has been determined. Students who get a score of 3 can state research procedures, and data collection techniques, and can state the instruments used. Students can identify the possible research participants in the defined situation. An example as follows:

> *"We used survey and literature review. This study included 323 students, 152 males and 171 females as research participants. The participants' ages ranged from eight to fifteen years old. A questionnaire is used in this study to measure variables based on the replies and conditions of the participants."*

Based on this sample answer, students might conclude that a survey is one feasible research design. Questionnaires were used to gather information about participants' personal hygiene habits. Students who partially accurately recognize variables and determine problem-solving design based on data (score of 2) showed that they can mentioned data collection tool but failed to describe possible research design. The student only stated that the research used questionnaire to gather the data:

> *"The present research depicts students that are infected with soil-transmitted helminth. Students answer the questionnaire."*

Students who received a score of 1 (46% of students) showed that they incorrectly identified factors and established problem-solving strategies based on data. They failed to recognize possible participants in the research or stated data collection methods.

Transforming

Transformation skills involve the analysis of data. Students are expected to create and turn data into words or figures. This information is required so that they can provide a more detailed explanation of the data. Furthermore, they can make the data more understandable. Figure 2 showed student sample answer that can identify and converted graphical representation accurately. They can made data visualization with suitable labels.

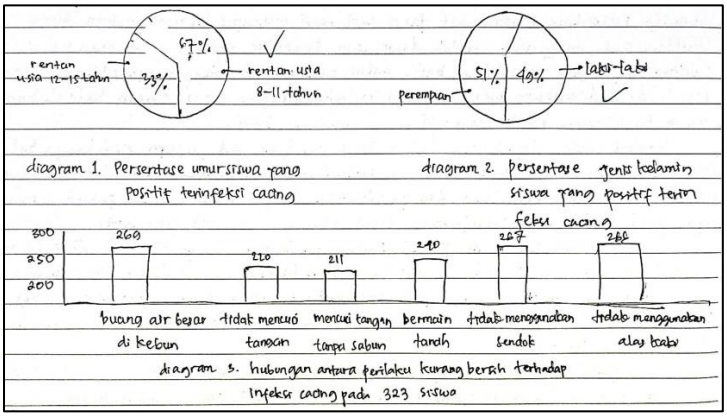

Figure 2. Student sample answer on transforming category (score of 3)

Students who receive score of 2 can identify and converted graphical representation with some errors (Figure 3). Students can transform data with some errors, such as they were not adding complete data label and not choosing suitable data visualization.

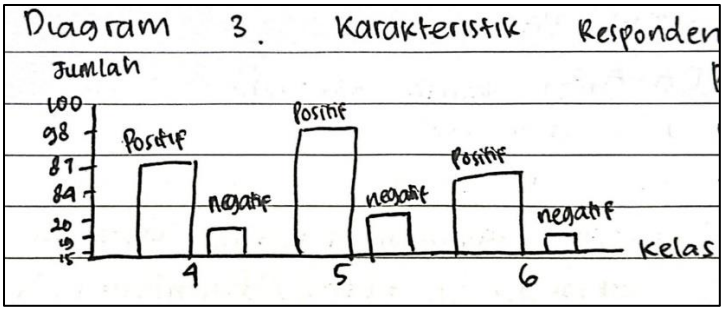

Figure 3. Student sample answer on transforming category (score of 2)

In transformation skills, up to 76% of students incorrectly identified and converted graphical representations (score of 1). Students merely rewrite the results they acquired, without any data modification. In addition to performing data transformations, students in this transformation category are expected to be able to explain data. However, this skill remains restricted.

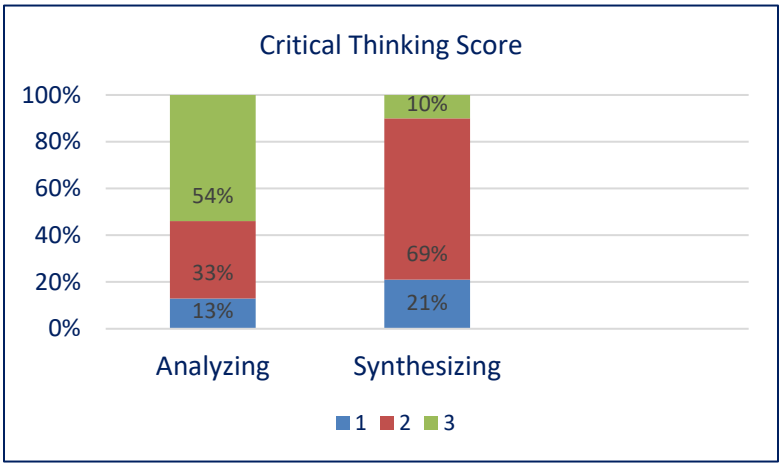

Figure 4. Students rubric score from critical thinking category

Analyzing

Analyzing skills involve explaining facts and investigating potential meanings of information to make statements that can be used as evidence to support claims. Students who received score of 3 showed that they can correctly processed data to establish meaning and produce meaningful evidence (54% of students). This student's response can explain the data and is consistent with the issue formulation posed. In describing the results, the student wrote:

> *"The data show that 48 participants were infected with roundworms (Ascaris lumbricoides), 106 with pond worms (Trichuris trichura), and 115 with mixed worms (roundworms and pond worms). This worm infection spreads through worm-infested vegetables and other foods.This was noted from the state of the toilets used by the participants, specifically open toilets in the plantation area based on the questionnaire responses."*

Student who partially accurate analyze data to find meaning and create relevant evidence (score of 2) showed that they can explain the data. However, the data they analyzed not complete. Students who received score of 1 showed they inaccurate analyze data to find meaning. They were only stated their opinion based on the result or they only rewrite the data presented.

Synthesizing

Synthesizing skills involve discovering relationships between several pieces of information and integrating them into a conclusion. As many as 10% of students were able to correctly develop conclusions after integrating the material (score of 3). The following statement of one of accurate conclusion based on the data:

> *"Personal hygiene involves hand washing, nail trimming, and cleaning. This is directly related to avoiding worm infestations in oneself. Environmental sanitation, including sanitation of clean water sources, toilets, and food hygiene, plays a role in STH transmission."*

Student who partially accurate generate conclusion by integrating the data (score of 2) wrote:

> *"According to the study's findings, STH infection in children is common since many children lack awareness about personal hygiene. There is correlation between STH infection and personal hygiene. It may be shown that affected students do not practice personal hygiene. As a preventive measure for STH in primary schools, there is a need to teach personal hygiene to schoolchildren through counseling."*

Students can draw conclusions based on these example answers, but their answers contradict the evidence. The evidence does not show that there is a link between STH infection and personal hygiene, despite the two aspects appearing to be associated. More research is needed to determine whether STH infection is related to personal hygiene. Students who received score of 1 showed they inaccurate generate conclusion They were only stated their opinion based on the result.

Scientific literacy

Scientific literacy abilities in data processing demonstrate that students incorrectly perceive scientific problems or arguments, incorrectly detect variables and decide problem-solving designs based on data, and incorrectly identify and convert graphical representations. However, in critical thinking skills, up to 33% of pupils partially accurately analyze facts to establish meaning and provide appropriate evidence (scoring 2). Students can do data-driven analyses, and there are suggestions for combining the results with issue formulation, but the information is incomplete. The students' conclusions are still relevant to the problem formulation, although they contain a few inaccuracies or are not clear.

Scientific writing can be used as an appropriate assessment for student research experiences (Mantai et al., 2024; Opitz et al., 2017). This writing task teaches students about the process of obtaining evidence and, lastly, how to develop a thoughtful argument that demonstrates logical reasoning based on the outcome (Clabough & Clabough, 2016). Scientific writing on microbiology subjects for midwifery students is crucial because it provides students with scientific insight into health issues that arise in society, making them more conscious of health literacy (Creedy et al., 2021)

The limitation through this work that we have evidence that students still develop their understanding about microbiology and research about microbiology in public health. We can not make claims about the generalness of the construct based on the data presented here. For further research we need to measure students' scientific numeracy so we can understand students' skill to transform and analyze the data.

D. CONCLUSION

Scientific writing on microbiology topic can revealed midwifery undergraduate students' scientific literacy. Students' critical thinking skill demonstrate their ability to examine the data, but their skills in problem identification and data transformation remain limited. Further research is required to address students' scientific numeracy skills in transforming and analyzing data.

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