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PROFILE OF EPISTEMIC SCIENCE ASSESSMENT EXPERIENCES: SCIENTIFIC REASONING IN BIOLOGY LEARNING

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Abstract

This study aimed to describe students' scientific reasoning assessment experiences in high school biology learning. The study employed a descriptive quantitative method involving 216 eleventh-grade students from A- and B-accredited senior high schools in Bandung and Cimahi. Data were collected through assessment experience questionnaires using a Likert scale and semi-structured interviews as supporting data. Data analysis was conducted descriptively for each sub-element of assessment experience. The results showed that students' assessment experiences were categorized as moderately good, with score ranges from 2.41 to 2.77. The highest scores were found in assessments measuring scientific reasoning types as well as social and technological contexts, while the lowest scores were found in controlled experimental design. Interview results indicated that biology assessments had begun to incorporate real-life contexts and data analysis; however, assessment experiences based on scientific investigation were still not evenly implemented.

***Keyword**: Epistemic; Assessment; Scientific Reasoning*

A. Introduction

Twenty-first century science learning not only aims to help students master concepts, but also to equip them with epistemic competencies as preparation for facing various real-life problems. OECD (2023) identifies epistemic knowledge as an important dimension of scientific literacy that supports students' ability to evaluate information, use evidence, and construct logical scientific explanations. Epistemic mastery helps students understand that scientific knowledge is acquired through processes of inquiry, argumentation, and evidence evaluation, rather than merely as a collection of facts to be memorized.

Epistemic competence is related to the ability to understand how scientific knowledge is constructed and validated. OECD (2023) explains that this competence includes the ability to interpret evidence, evaluate scientific arguments, understand the use of models and theories, and reflect on changes in knowledge based on new evidence. Scientific reasoning is an important part of epistemic competence because it involves the use of logic and evidence in constructing and evaluating scientific explanations (Krell *et al*., 2022). Therefore,

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biology learning should provide experiences that encourage students to conduct investigations, evaluate evidence, and develop meaningful scientific arguments.

Students' mastery of scientific reasoning is strongly influenced by their assessment experiences at school. Assessment plays a strategic role in shaping how students learn and develop scientific thinking skills, including identifying variables, formulating hypotheses, and evaluating evidence (Qadar *et al*., 2025; Vo dan Simmie, 2025). Appropriate assessments provide meaningful feedback that helps students improve their scientific reasoning abilities and epistemic reflection. For example, formative assessment encourages students to reflect on their thinking processes, enabling them not only to know the outcomes but also to understand how knowledge is constructed from evidence (Mihelic dan Zore, 2022; OECD, 2023).

Assessment results also help teachers adjust learning strategies based on students' experiences and needs, allowing weaknesses in scientific reasoning to be addressed more effectively (Sardag dan Cakmakci, 2025). Currently, biology learning and assessment practices in schools still tend to focus on concept memorization and final learning outcomes. The evaluation instruments used are also still dominated by multiple-choice questions that emphasize lower-order cognitive skills, making them less capable of exploring students' scientific thinking processes in depth (Widarta *et al*., 2023). As a result, students' opportunities to develop evidence-based argumentation and epistemic reflection remain limited.

Research on scientific reasoning has mostly focused on the development of learning models and assessment instruments, while studies examining students' scientific reasoning assessment experiences in schools are still relatively limited. Meanwhile, mapping assessment experiences is important for identifying gaps between learning objectives and the assessment practices experienced by students in the classroom (Fatimah *et al*., 2026; Krell *et al*., 2022). Therefore, this study was conducted to describe students' scientific reasoning assessment experiences in biology learning at school. Through this study, it is expected that the extent to which scientific reasoning assessments have been implemented in biology learning can be identified. The findings are expected to provide a basis for developing more effective assessments to support students' scientific thinking skills and epistemic competence.

B. Methodology

This study employed a quantitative approach using a descriptive method. The population of this study consisted of eleventh-grade senior high school students in Bandung and Cimahi. The sample was selected using purposive

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sampling to ensure that the chosen schools met the criteria of being accustomed to implementing scientific inquiry or laboratory-based learning, as well as aligning with the research objective regarding scientific reasoning assessment experiences in biology learning. A total of 216 eleventh-grade students from A- and B-accredited schools participated in this study. The selection based on school accreditation was intended to ensure that the study could capture diverse perspectives and conditions, thereby providing more comprehensive and representative findings. To obtain the required data, the instrument used in this study was a closed-ended questionnaire consisting of 19 statement items based on indicators of scientific reasoning mastery, using a Likert scale with the following criteria: 1 = never, 2 = rarely, 3 = often, and 4 = always.

The data in this study were analyzed using descriptive quantitative. The categories of students' assessment experiences obtained through the Likert-scale questionnaire were determined based on the range of respondents' average scores. The categorization intervals were established according to the Likert scale calculation proposed by Sugiyono (2020), resulting in the categories of never, rarely, often, and always, as presented in the following table.

Table 1. Score Interpretation Categories

Svore Range	Categories
1,00 – 1,75	Never
1,76 – 2,50	Rarely
2,51 – 3,25	Frequently
3,26 – 4,00	Always

C. Results and Discussion

1. Results

The study was conducted by distributing an assessment experience questionnaire consisting of 19 statement items to all research participants from 10 senior high schools in Bandung and Cimahi, involving a total of 216 students. The questionnaire results were used to describe students' experiences in each measured sub-element. In addition, this study also compared students' assessment experiences based on school accreditation. To provide a more detailed description of students' assessment experience levels in each sub-element, the scores were analyzed based on the mean scores obtained. The analysis was also presented by comparing experiences between A- and B-accredited schools to identify possible differences or particular trends.

Figure 1. Average Assessment Experience Score for Each Sub-Element

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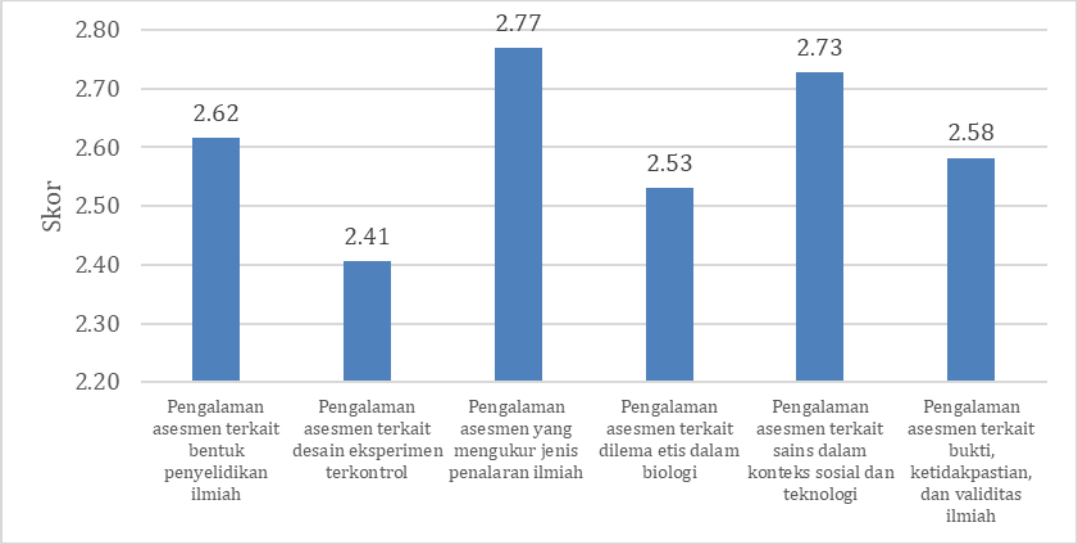
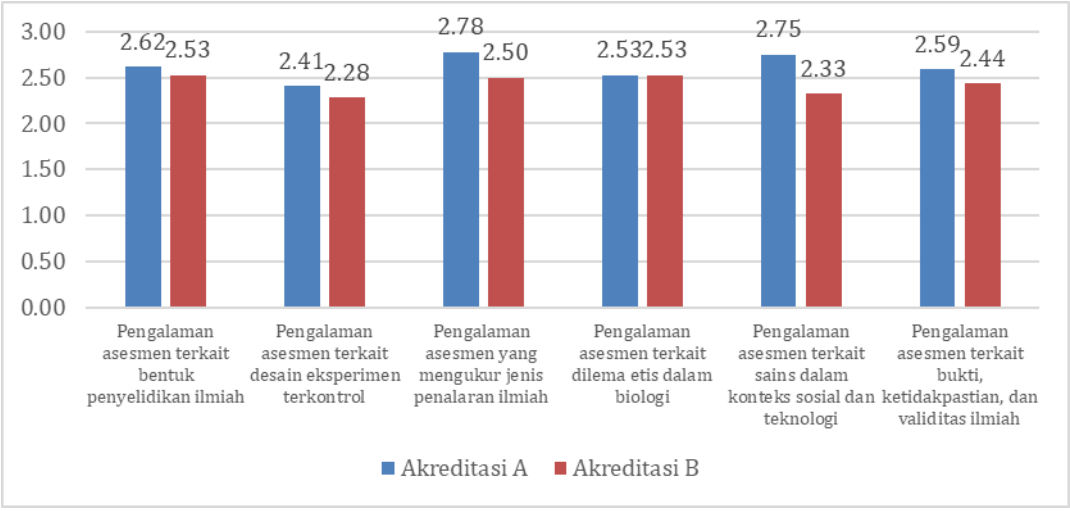


Figure 1 shows that students' assessment experience scores were categorized as moderately good, with variations across sub-elements. The highest scores were found in assessments measuring scientific reasoning types (2.77), categorized as frequently practiced, as well as in social and technological contexts, indicating that students more frequently encountered assessments based on reasoning and real-life contexts. In contrast, the lowest score was found in controlled experimental design (2.41), indicating that assessment experiences related to this aspect were still rarely practiced.

Figure 2. Comparison of Assessment Experience Scores for Each Sub-Element Based on School Accreditation



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Based on Figure 2, the pattern of students' assessment experiences across each sub-element showed relatively consistent trends between A- and B-accredited schools. In general, A-accredited schools obtained slightly higher scores than B-accredited schools in most sub-elements. However, the differences were not substantial, indicating that the assessment experiences received by students in both school categories were relatively comparable.

In addition, all sub-elements showed relatively small variations in achievement, indicating that scientific reasoning assessment experiences had been implemented quite evenly across various aspects. Although several sub-elements appeared to have higher scores than others, overall there were no extreme differences either among sub-elements or between school accreditation categories. This finding suggests that the implementation of assessments supporting scientific reasoning has been carried out, although it still has the potential to be improved to become more optimal and evenly distributed.

Table 2. Average Student Assessment Experience Score Based on School Accreditation

Sub Element	Average		Highest Average		Lowest Average	
	A	B	A	B	A	**B**
Assessment experience related to forms of scientific inquiry	2.62 (frequently)	2.53 (frequently)	4.00 (always)	3.33 (always)	1.33 (never)	1.67 (never)
Assessment experience related to controlled experimental design	2.41 (rarely)	2.28 (rarely)	4.00 (always)	3.33 (always)	1.00 (never)	1.67 (never)
Assessment experiences that measure types of scientific reasoning	2.78 (frequently)	2.50 (rarely)	4.00 (always)	3.75 (always)	1.25 (never)	1.75 (never)
Assessment experiences related to ethical dilemmas in biology	2.53 (frequently)	2.53 (frequently)	4.00 (always)	3.67 (always)	1.00 (never)	2.00 (rarely)
Assessment experiences related to science in social and technological contexts	2.75 (frequently)	2.33 (rarely)	4.00 (always)	3.33 (always)	1.33 (never)	1.33 (never)
Assessment	2.59	2.44	4.00	4.00	1.00	2.00

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Sub Element	Average		Highest Average		Lowest Average	
	A	B	A	B	A	**B**
experience related to evidence, uncertainty, and scientific validity	(frequently)	(rarely)	(always)	(always)	(never)	(rarely)

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Based on Table 3, it can generally be seen that students' assessment experiences across all sub-elements were relatively similar between A- and B-accredited schools, although scores in A-accredited schools tended to be slightly higher. This indicates that students in both school categories had obtained fairly diverse assessment experiences, covering aspects of scientific inquiry, experimental design, and the evaluation of scientific evidence. Nevertheless, the relatively small differences in scores suggest that the implementation of scientific reasoning assessments in both types of schools remained at a relatively comparable level. Overall, these findings also indicate that assessment experiences supporting scientific reasoning have begun to be implemented, although no significant gap was found between school accreditation categories.

2. Discussion

The results showed that students' scientific reasoning assessment experiences were categorized as moderately good, although variations were still found across each sub-element. Assessment experience is an important aspect of learning because appropriate assessment not only functions to measure learning outcomes, but also provides meaningful information and feedback for students regarding their strengths and weaknesses. Through assessment, students can identify aspects that need improvement, helping them improve their learning strategies, thinking processes, and overall learning experiences. This finding is in line with Day *et al*. (2021), who stated that appropriate assessment design and feedback can improve learning quality and student achievement more effectively. In addition, OECD (2023) also emphasized that science assessment should support the development of scientific thinking skills through the use of evidence, reflection, and evaluation of scientific processes.

The highest scores were found in assessments measuring scientific reasoning types as well as social and technological contexts, indicating that students more frequently encountered assessments requiring reasoning and the application of scientific concepts in real-life situations. Interview results supported these findings. Several students stated that they had completed assignments related to environmental pollution, waste management, detergent use, and healthy lifestyles connected to everyday life. Students felt that these assignments helped them understand the application of biological concepts and increased their awareness of environmental issues. In addition to helping students understand concepts, contextual assessment also provided more reflective learning experiences because students were able to relate

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assessment results to real conditions around them. These findings indicate that contextual assessment can make learning more meaningful for students. This result is consistent with Luo *et al*. (2020), who stated that scientific reasoning assessments based on reasoning and the use of evidence can help develop students' scientific thinking skills. Furthermore, the use of real-life contexts in learning and assessment is also known to support the development of scientific reasoning and scientific literacy (Asri *et al*., 2025; García-Carmona, 2025; OECD, 2023). The use of contextual problems and problem-based learning has also been shown to improve students' scientific literacy and scientific thinking skills (Asri *et al*., 2025; Taqiya *et al*., 2024). In addition, students' argumentation and scientific reasoning skills develop better when learning and assessment involve scientific issues from everyday life (Chatimah *et al*., 2019; Karlina dan Alberida, 2021).

In contrast, the lowest scores were found in the controlled experimental design sub-element. Interview results showed that some students had conducted simple laboratory activities such as cell observation, plant identification, and salted egg production, involving observation, experimental procedures, and result analysis. This finding is consistent with studies by Arnold *et al*. (2023), Blumer dan Beck (2019), and Chengere *et al*. (2025), which showed that inquiry-based laboratory activities can improve students' experimental design and scientific reasoning skills. However, several students admitted that they had never or rarely carried out experimental assignments. This indicates that assessment experiences based on scientific investigation have not been evenly implemented and that learning still tends to focus more on conceptual mastery than on scientific investigation practices. As a result, students have fewer opportunities to receive feedback regarding their ability to design experiments, control variables, and evaluate scientific procedures. In fact, assessment experiences involving scientific investigation are important for helping students improve their scientific thinking processes and inquiry skills. These findings are in line with Hicks *et al*. (2020), who stated that experimental design skills remain a challenge for students. The low level of students' experiences in this aspect is also consistent with studies by Aulia Handayani *et al*. (2020), Charysma *et al*. (2018), and Nabillah *et al*. (2022), which showed that high school students' scientific reasoning abilities are still at moderate to low levels.

In addition, most students stated that they were accustomed to drawing conclusions from practical activities or

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data analysis. These activities helped students understand the material and train their scientific thinking skills, although some students still experienced difficulties in analyzing data and graphs. These findings are consistent with Bao *et al*. (2022) and Fechter *et al*. (2021), who explained that inference-making and scientific reasoning skills develop through consistent practice in data analysis, information evaluation, and the use of scientific evidence. This indicates that assessments involving data interpretation and scientific inference have begun to be implemented, although they still need to be strengthened. Through assessments involving data interpretation, students can identify their analytical abilities while also recognizing aspects that need improvement in their scientific thinking processes.

Based on Figure 2 and Table 2, students' assessment experiences in A- and B-accredited schools showed relatively similar trends. The differences in scores between schools were not substantial, indicating that assessment experiences were more influenced by teachers' learning and assessment strategies than by school accreditation status. This finding suggests that the quality of assessment experiences is determined not only by school facilities, but also by how teachers design assessments that provide meaningful feedback and learning experiences for students. Ramli *et al*. (2021) also showed that dynamic assessment can help develop students' reasoning skills through active scientific thinking activities. In addition, Day *et al*. (2021) emphasized that appropriate assessment design and feedback can improve learning quality and student success more effectively.

Overall, the implementation of scientific reasoning assessment has begun to be applied, although it still needs to be improved to become more optimal. Assessment should not only measure conceptual mastery, but also provide opportunities for students to interpret data, evaluate evidence, and construct scientific conclusions. In addition, effective assessment should provide feedback that helps students understand their weaknesses and improve their learning experiences and scientific thinking processes. This finding is supported by Krell *et al*. (2022), who emphasized that scientific reasoning needs to be developed through assessments that represent scientific competencies more comprehensively. Furthermore, studies by Rahmi *et al*. (2025) and Dewi *et al*. (2025) showed that the development of epistemic assessment in biology learning is important for supporting students' higher-order thinking skills. Therefore, the development of assessments based on scientific investigation, scientific

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argumentation, and contextual problem-solving should continue to be carried out to support the optimal development of students' scientific reasoning skills.

D. Conclusion

Based on the results of the study, the scientific reasoning assessment experiences of senior high school students in Bandung and Cimahi were categorized as moderately good. Students more frequently received assessments that required scientific reasoning and the application of biological concepts in everyday life contexts, such as environmental pollution issues, waste management, and the analysis of laboratory activity results. However, assessment experiences related to controlled experimental design were still relatively low because some students rarely conducted investigations or designed experiments independently. In addition, assessment experiences in A- and B-accredited schools showed relatively similar patterns, indicating that assessment implementation was influenced more by teachers' learning and assessment strategies than by school accreditation status. Therefore, teachers need to improve the implementation of assessments based on scientific investigation, scientific argumentation, data analysis, and contextual problem-solving to support the more optimal development of students' scientific reasoning skills. Future studies are also recommended to examine the implementation of scientific reasoning assessments more deeply within classroom learning processes.

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