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Strengthening Student Science Literacy Based on Experience and Discovery Learning through Cascara Kombucha Fermentation Research

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Abstract

Objective: *This study aims to describe the results of group assessments in experiential learning activities and to analyze individual discovery-learning abilities using the Claim–Evidence–Reasoning (CER) rubric to strengthen students' science literacy in the context of cascara kombucha fermentation research.* ***Method:*** *The study used a descriptive quantitative design supported by qualitative data. The subjects, divided into five groups, participated in a seven-day cascara kombucha fermentation experiment. Data were obtained through group assessments for experiential learning and individual CER-based assessments for discovery learning, then analyzed using descriptive statistics and qualitative interpretation.* ***Results:*** *The group assessment results showed adequate ability with an average score of 72.7–79.7, with group 3 obtaining the highest score. The CER assessment showed that 20 students were in the insufficient category and 10 students were in the high category, with none in the "low" category.* ***Novelty:*** *The integration of experiential learning and discovery learning in kombucha fermentation research has been proven to strengthen students' scientific literacy and the quality of their scientific arguments. In addition, the CER rubric is effectively used as an evaluation standard to monitor the development of scientific reasoning in science learning.*

Abstrak

Tujuan: Penelitian ini bertujuan mendeskripsikan hasil penilaian kelompok pada kegiatan experiential learning dan menganalisis kemampuan discovery learning individu berdasarkan rubrik *Claim–Evidence–Reasoning* (CER), untuk penguatan literasi sains mahasiswa pada penelitian fermentasi kombucha cascara. **Metode:** Penelitian menggunakan desain kuantitatif deskriptif dengan dukungan data kualitatif. Subjek terdiri dari 30 mahasiswa S1 Pendidikan Biologi yang dibagi menjadi lima kelompok dan mengikuti penelitian fermentasi kombucha cascara selama tujuh hari. Data diperoleh melalui penilaian kelompok untuk experiential learning dan penilaian individu berbasis CER untuk discovery learning, kemudian dianalisis menggunakan statistik deskriptif serta interpretasi kualitatif. **Hasil:** Penilaian kelompok menunjukkan kemampuan kategori cukup dengan rata-rata nilai 72,7–79,7. Kelompok 3 memperoleh nilai tertinggi. Penilaian CER menunjukkan 20 mahasiswa dengan kategori cukup dan 10 mahasiswa denngan kategori tinggi, dan tidak ada pada kategori rendah. **Kebaruan:** Integrasi experiential learning dan discovery learning pada penelitian fermentasi kombucha terbukti menguatkan literasi sains serta kualitas argumentasi ilmiah mahasiswa. Selain itu, rubrik CER efektif digunakan sebagai standar evaluasi untuk memantau perkembangan penalaran ilmiah dalam pembelajaran sains.

Introduction

Science literacy is the ability to understand scientific concepts, use empirical evidence, and apply scientific reasoning to explain phenomena and make science-based decisions.[1] . Science literacy is a core competency for prospective biology educators, enabling them to teach the scientific process authentically in schools. Biology is oriented towards developing students' logical and analytical thinking skills and combines theoretical and practical activities.[2] . The learning process for students as prospective biology educators is necessary by developing direct learning experiences based on the scientific method, namely, connecting theory with real phenomena. Experiential and discovery learning offer an integrated approach by placing students at the center of the scientific process to encourage deeper understanding and retention [3]. Experiential learning, such as participating in community-based scientific projects, helps students connect classroom learning with real-world applications. This method not only enhances scientific literacy but also encourages lifelong learning [4]. Scientific literacy for students is crucial for developing high-quality talent.[5] .

Students observe real phenomena, design experiments, analyze data, and construct evidence-based arguments. Integrating technology into learning to help students who have difficulty with science literacy and provide additional resources to improve their understanding of scientific concepts [6]. The context of cascara kombucha fermentation was chosen because it provides biological processes that can be observed directly, such as microbial activity, pH changes, gas formation, and metabolite dynamics. This study aims to describe the results of group assessments in experiential learning activities and analyze individual *discovery-learning abilities using the Claim–Evidence–Reasoning (CER) rubric* to strengthen students' science literacy.

Method

The research used a descriptive quantitative design supported by qualitative data, without any intervention. The focus of the study was to analyze student learning outcomes after participating in a series of experience- and discovery-based learning activities. The research subjects consisted of 30 undergraduate students majoring in Biology Education at the Faculty of Teacher Training and Education, Balitar Islamic University, divided into five groups. All students participated in a 7-day kombucha cascara fermentation experiment.

Learning Procedure

1. Direct Experience (*Experiential Learning*)
   a. Observing fermentation phenomena, including color, aroma, pH, and CO_2activity.
   b. Calibrating and using a pH meter.
   c. Developing a plan for the cascara kombucha fermentation experiment.

d. Recording daily observation data

2. D*iscovery Learning*

a. Formulating hypotheses based on initial data.

b. Analyzing pH change graphs.

c. Developing scientific arguments using the *Claim–Evidence–Reasoning* (CER) format.

Research Instruments

1. Group assessment sheets for *experiential learning* skills. Experiential *Learning* consists of explaining phenomena, designing investigations, and interpreting data.

a. Group Assessment Rubric Explaining Phenomena

Table 1. Description of Scores Based on the Group Assessment Rubric for Explaining Phenomena

Level	Description	Score
Very Good	Explains the entire phenomenon (color, aroma, pH, CO_2 activity) in detail and relates it to microbiology or biochemistry concepts.	**90–100**
Good	Explains the main phenomena clearly enough, but the relationship between concepts is not yet fully explored.	**80–89**
Fair	Explains the phenomenon in general terms, only mentioning changes without strong scientific reasoning.	**70–79**
Poor	Explains the phenomenon without linking it to the concept of fermentation and is unclear.	**<70**

b. Group Assessment Rubric for Experiment Design

Table 2. Description of Scores Based on the Group Assessment Rubric for Designing Investigations

Level	Description	Score
Excellent	Complete design: controlled variables, clear work steps, safety measures listed, appropriate tools and materials.	**90–100**
Good	The design is quite clear and straightforward, but some variables or work steps are not detailed.	**80–89**
Fair	Variables or controls are incomplete, and work steps are still general.	**70–79**
Poor	Design is not systematic, and variables are unclear.	**<70**

c. Group Assessment Rubric Interpreting Data

Table 3. Description of Scores Based on Group Assessment Rubric for Interpreting Data

Level	Description	Score
Very Good	Accurate analysis of graphs and tables, identifying anomalies and providing strong scientific reasoning.	**90–100**
Good	Analysis is mostly correct, but does not mention errors or trends in detail.	**80–89**
Fair	The fundamental analysis is correct, but it lacks connection to scientific concepts.	**70–79**
Insufficient	Concludes without strong data support.	**<70**

2. CER (*Claim–Evidence–Reasoning*) rubric for *discovery learning* skills with a scale of 0–3 ( ).

a. Claim Assessment Rubric

Table 4. Description of Scores Based on the Claim Rubric

Score	Score Description
0	No *claim* made, or the content of the claim is not relevant to the question/issue being examined.
1	*The claim is* very general or vague; it does not demonstrate an understanding of the focus of the cascara kombucha fermentation issue.
2	*The claim is clear, precise, and answers the research question,* but does not include conditions or limitations.
3	*Claims* are very specific, focused, and include conditions/scope, demonstrating mature scientific thinking.

b. Evidence Assessment Rubric

Table 5. Description of Scores Based on the Evidence Rubric

Score	Score Description
0	No data provided at all or data is irrelevant to *the claim*.
1	Evidence in the form of data is very limited or irrelevant; does not mention measurement instruments.
2	Data are sufficiently complete and relevant, and they mention the data source or instrument (e.g., pH meter).
3	Evidence is it replication of measurements.

c. *Reasoning* Assessment Rubric

Table 6. Description of Scores Based on the *Reasoning* Rubric

Score	Score Description
0	There is no logical connection between *the evidence* and *the claim*; no concepts are used.
1	The relationship between *evidence* and *claim is* weak; the use of concepts is inappropriate.
2	*Reasoning* is appropriate and connects evidence to *claims* using biological or biochemical concepts.
3	*Reasoning* is strong; it explains the mechanism in detail and considers sources of error or alternative interpretations.

Table 7. Description of the category based on the CER rubric assessment

Category	Score Range	Description of Value
Low	**0–3**	Students are not yet able to construct adequate scientific arguments; claims are unclear, evidence is minimal, reasoning is inaccurate, and the writing's structure is lacking.
Fair	**4–6**	Students can construct basic scientific arguments; claims are explicit, evidence is relevant, and reasoning is reasonably sound, though not yet in-depth. Scientific communication is well-written.
High	**7**	Students demonstrate mature scientific argumentation skills: strong, specific claims, comprehensive evidence, detailed reasoning, and excellent communication, supported by scientific visuals.

Data Analysis

a. Quantitative data is analyzed using descriptive statistics (mean, categories).
b. Qualitative data were obtained from lecturers' observation notes and students' CER descriptions.

Results

The group assessment results indicate the experiential learning abilities of undergraduate students in biology education at Balitar Islamic University in explaining phenomena, designing investigations, and interpreting data, as shown in Table 8.

Table 8. Group Assessment Results of Students for *Discovery Learning* Ability

Group	Explaining Phenomena	Designing Experiments	Interpreting Data	Average
1	78	76	79	77.7
2	74	72	75	73.7
3	80	78	81	79.7
4	73	71	74	72.7
5	77	75	78	76.7

Table 8 shows that the average group score ranged from 72.7 to 79.7, indicating students' ability to explain phenomena, design experiments, and interpret data in the context of cascara kombucha fermentation. Group 3 obtained the highest score, with a category of quite good. These findings confirm that experience-based learning can strengthen students' science literacy.

The number of undergraduate students majoring in Biology Education at Balitar Islamic University, based on individual assessments on the claim–evidence–reasoning rubric for discovery learning abilities, is shown in Figure 1.

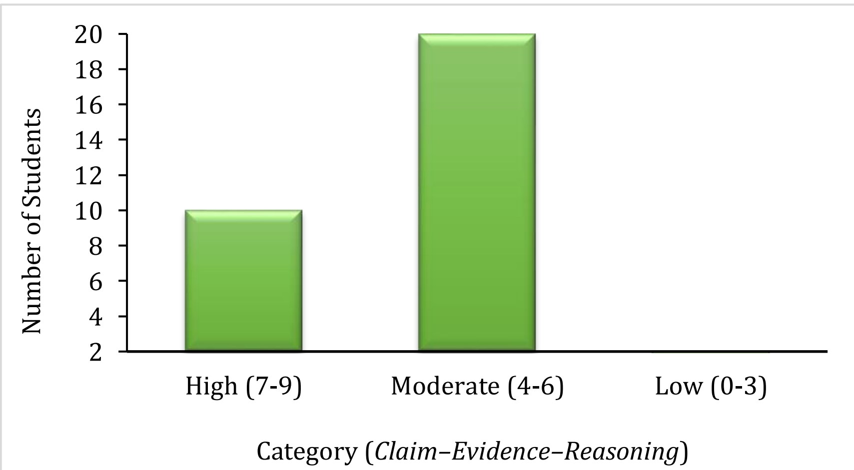

Figure 1. Distribution of students' scientific argumentation ability categories based on *Claim–Evidence–Reasoning* (CER) assessment.

Figure 1 shows the distribution of scientific argumentation skills among 30 students based on the *Claim–Evidence–Reasoning* (CER) assessment. Most students (20) were in the adequate category, while 10 students were in the high category. No students were in the low category. This distribution pattern indicates that most students can formulate claims, use evidence, and develop coherent scientific reasoning.

Discussion

The results of the study indicate that *experiential* and *discovery learning* contribute significantly to the development of students' science literacy. Students carried out a complete scientific process, from observation and measurement to data analysis and the preparation of evidence-based arguments in the study of cascara kombucha fermentation. The synergistic integration of *experiential* and *discovery learning* offers a powerful model for developing science literacy and contributing effectively to the scientific aspects of everyday life [7].

Applying the CER rubric provides a holistic view of its impact on students' academic performance, scientific writing skills, and perceptions, ultimately strengthening scientific literacy. Students gain a deeper understanding of scientific concepts by actively constructing explanations and arguments, often leading to better knowledge retention as a bridge between theoretical knowledge and practical application, making abstract concepts more tangible [8]. The dominance of the "adequate" category in students' CER scores indicates that some students still need to deepen their mechanistic reasoning skills and enrich the evidence they use. However, the absence of a "low" category suggests that integrating experiential and discovery learning can support students' basic argumentation skills.

Authentic and personally relevant *experiential learning* activities are more effective in increasing engagement because they incorporate critical thinking into learning [9], while *discovery learning* can strengthen critical thinking skills [10] and scientific reasoning. Thus, a combination of these two approaches can be an alternative method of teaching biology to students in courses that require an understanding of the scientific process.

Conclusion

The assessment of experiential learning in the context of cascara kombucha fermentation to strengthen students' science literacy based on group scores shows that the ability to explain phenomena, design experiments, and interpret data is categorized as adequate. Individual CER scores for discovery learning show a predominance of the "adequate" and "high" categories. CER scores indicate a good start in scientific argumentation skills for student science literacy in cascara kombucha fermentation research.

Recommendations

Biology education in higher education needs to integrate more broadly authentic phenomena, such as cascara kombucha fermentation, to strengthen science literacy. To improve the quality of scientific argumentation, learning support that prioritizes evidence-based reasoning through the CER approach needs to be emphasized so that students' abilities can develop to a higher level. In addition, the CER rubric is recommended as a standard assessment framework used consistently to monitor the development of scientific reasoning and ensure alignment with international science education standards.

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