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Analysis and Reconstruction of the Practicum Worksheet 'The Effect of Temperature on Catalase Enzyme Activity'

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ABSTRACT

Practicum is essential for developing students' cognitive, affective, and psychomotor skills, making it a fundamental aspect of biology learning. By engaging in practicum activities, students can explore important biological concepts, such as the activity of the catalase enzyme, which helps deepen their understanding and involvement with the concept. This study aims to analyze the practicum worksheet on catalase enzyme activity, specifically focusing on the effect of temperature on catalase activity. The analysis is conducted using Novak & Gowin's Vee Diagram, which includes focus question, object/event, theory/concept, record/transformation, and knowledge claim. The analysis of the worksheet showed that the practicum procedure was less directed, and students were unable to relate the practicum activities to the underlying concepts. The reconstruction of the practicum procedure is carried out to ensure that the activities align with the fundamental concepts being studied. This research can assist teachers in designing more effective practicum worksheets that align with biological concepts and enhance students' understanding of the relationship between theory and practice. Analysis using the Novak & Gowin Vee Diagram can deepen students' knowledge of the effect of temperature on catalase enzyme activity and improve students' analytical skills.

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1. INTRODUCTION

Biology is a subject in high school that frequently involves students in practicum activities. Through practicum activities, abstract biology concepts will be more easily understood by students (Inayah et al., 2022; Jumrodah et al., 2023; Putri et al., 2020). These activities also assist teachers in developing hands-on learning experiences (Dewi et al., 2014), resulting in meaningful learning for students. Compared to classroom learning, which primarily focuses on cognitive skills, practicum activities allow students to simultaneously develop their cognitive, affective, and psychomotor abilities (Hadiati et al., 2020). This is supported by the scientific methods used in practicums, such as following practicum procedures, directly observing objects, analyzing results, and proving theories to draw conclusions (Atmanegara et al., 2017). According to Lafenasti (2018), optimally conducted practicum activities can help achieve the desired learning objectives.

However, if practicum activities are not conducted effectively, students' psychomotor skills may not develop adequately (Oktavia et al., 2012; Rahman et al., 2015).

In order for students to experience meaningful learning and achieve learning objectives, practicum activities must align with the underlying concepts and theories. Unfortunately, practicum activities often encounter obstacles, including those in biology learning. According to Rahmah et al. (2021), one obstacle in biology practicums is the teachers' inadequate understanding. Teachers' inability to connect practicum activities with the underlying concepts and theories impedes the smooth implementation of practicum activities and renders them suboptimal. Apart from that, improper development of practicum worksheets, such as inconsistencies in titles, practicum procedures, data recording, and practicum questions, also poses challenges in practicum activities that require attention (Putri et al., 2020).

One of the practicums in biology learning that often encounters challenges is the catalase enzyme practicum (Deratama et al., 2020). Concepts regarding enzymes are part of metabolism material that is difficult for teachers to convey due to their abstract nature (Lestari et al., 2020). According to Sanjaya et al. (2015), the catalase enzyme practicum emphasizes students' mastery of the practicum procedures, where they are required to understand enzyme properties, factors affecting enzyme activity, and enzyme roles in our body. Several previous studies revealed that the development of catalase enzyme practicum worksheets used in schools often does not meet the criteria for good practicum worksheets, thus requiring reconstruction (Deratama et al., 2020; Inayah et al., 2022; Lestari et al., 2020; Setiawan et al., 2022). However, most previous studies have only conducted general analyses or reconstructed general factors that may affect the activity of catalase enzymes (such as pH and temperature) without specifically focusing on temperature, resulting in procedures that are often less complex. This study found discrepancies between the procedure in the practicum worksheet on the effect of temperature on catalase enzymes and the underlying concepts and theories. Based on this, an analysis and reconstruction of the catalase enzyme practicum is needed to optimize practical activities in biology learning.

2. METHOD

This research utilized a qualitative descriptive method. We selected samples in the form of catalase enzyme practicum worksheets used by one high school in Bandung City. The practicum worksheets were analyzed and reconstructed through several stages (Supriatno, 2018). The research flow is illustrated in Figure 1 below.

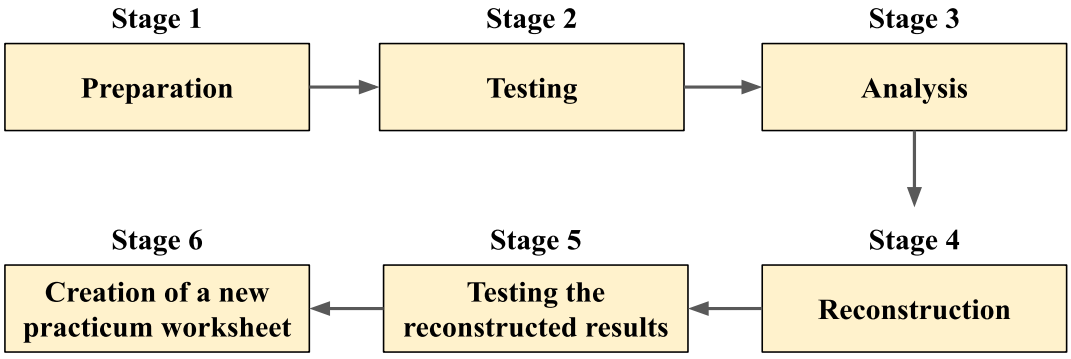

Figure 1. The Research Flow

After the catalase enzyme practicum worksheet is prepared (stage 1), the practicum is tested according to the procedure to assess the effect of temperature on catalase enzyme activity (stage 2). Based on the results, an analysis of the practicum worksheet is performed according to Novak and Gowin's Vee Diagram for knowledge reconstruction (stage 3). The reconstructed results are tested (stage 5) until a more effective practicum worksheet is developed for analyzing the effect of temperature on catalase enzyme activity. The Novak and Gowin Vee Diagram used for analyzing the practicum worksheet are illustrated in Figure 2.

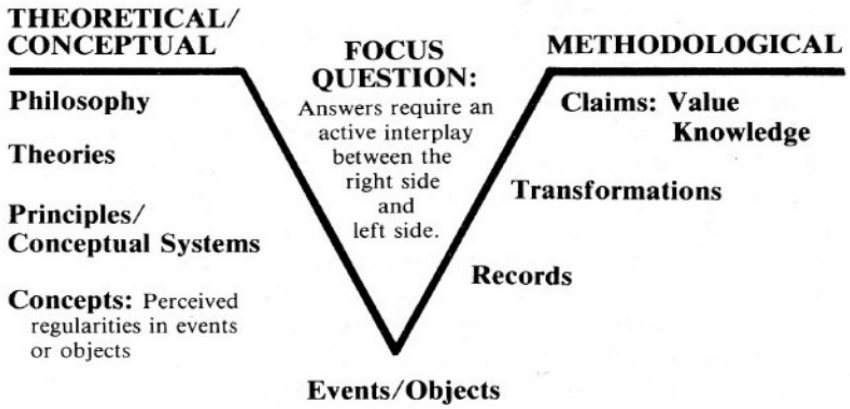

Figure 2. Novak & Gowin Vee Diagram (1984)

3. RESULTS AND DISCUSSION

3.1. Analysis of the Practicum Worksheet: The Effect of Temperature on Catalase Enzyme Activity

One aspect emphasized by Novak & Gowin (1984) is the aspect of knowledge reconstruction. According to Agustina et al. (2019), the knowledge reconstruction aspect aims to determine how objects and phenomena observed and recorded during the practicum can be used to build students' knowledge independently. The practicum worksheet was analyzed using a vee diagram. The components of the vee diagram analysis include the focus question, object/event, theory/concept, record/transformation, and knowledge claim. The analysis results show that the quality of the practicum worksheet received a score of 7 out of a maximum of 18, or 39%. This indicates that the practicum worksheet needs improvement. The rubric for assessing the catalase enzyme practicum worksheet can be seen in Table 1.

Table 1. Catalase Enzyme Practicum Worksheet Analysis Results

No	Vee Diagram Analysis Components	Score
1.	Focus question	1
2.	Object/event	1
3.	Theory/concept	0
4.	Record/transformation	3
5.	Knowledge claim	2
	Total Score	7
	Percentage	39%

In the first component, which is the focus question, the practicum worksheet scored 1 out of a maximum score of 3. There are several practicum questions in the practicum worksheet that are not aligned with the activities conducted, thus not guiding the acquisition of events or concepts. Ideally, focus questions should be directly related to the practicum steps taken to help understand the main concepts intended to be achieved. In the practicum worksheet, focus questions are crucial in assisting students in understanding the practiced material (Anggraini, 2016). A practicum worksheet with well-designed focus questions will help students link the conducted practicum procedures with their underlying concepts. In the second component, which is the object/event, the practicum worksheet scored 1 out of a maximum score of 3. The main research object was identified but was not consistent with the focus questions. This relates to the previous analysis, where there were focus questions that were not aligned with the conducted practicum activities. In the catalase enzyme activity practicum, the observed object is the bubbles and flame in the reaction tube as a result of catalyzing hydrogen peroxide into water and oxygen. While this object can be observed, the observation of the object is not supported by appropriate focus questions.

In the third component, which is the theory/concept, the practicum worksheet received a score of 0 out of a maximum score of 4 because the underlying theory/concept of the practicum activity was not stated. The absence of stated theory/concept in the practicum worksheet will impact the execution of the conducted practicum. Without stated theory/concept, students will struggle to build knowledge (Hindriana, 2016). Additionally, the process of linking concepts with practicum activities cannot be achieved. This aligns with the trial results conducted previously, where we identified inconsistencies between the practicum procedure and the basic theory of catalase enzyme because the used practicum worksheet did not include theory/concept as a reference for the practicum activity. In the fourth component, which is record/transformation, the practicum worksheet scored 3 out of a maximum of 4 points. In this aspect, the recording and transformation of practicum data are identified. The recorded practicum data corresponds to the observed events, the transformation is consistent with the focus questions, and the practicum activities conducted are appropriate for high school students. The record/transformation component in the catalase enzyme practicum worksheet is quite satisfactory. However, to further maximize the process of students' knowledge reconstruction, teachers can develop quantitative data collection methods for the practicum. According to Inayah et al. (2022), current catalase enzyme practicums conducted in schools still predominantly use qualitative data collection methods through observing bubbles and flames.

In the fifth component, which is knowledge claim, the practicum worksheet scored 2 out of a maximum of 4 points. The knowledge claim in the practicum worksheet is not consistent with the recorded or transformed data. To assess the knowledge claim, the relationship between the practicum questions and the existing theory/concepts is considered. Students can claim their knowledge if they can link their observations with theory and real-life contexts. Knowledge claim is crucial for fostering critical thinking skills in students.

3.2. Reconstruction Results of Practicum Worksheets: The Effect of Temperature on Catalase Enzyme Activity

After conducting the practicum test and analyzing the practicum worksheet based on the vee diagram, we attempted to reconstruct the practicum worksheet. Our main focus in the

reconstruction was the practicum procedure. The absence of theory/concepts listed in the practicum worksheet made the practicum procedure less directed. Therefore, we compiled a reconstruction of the catalase enzyme practicum worksheet by including theory/concepts and emphasizing the reconstruction of the practicum procedure. The theory/concepts added to the catalase enzyme practicum worksheet can be seen in Figure 3, while the reconstruction of the practicum procedure can be seen in Figure 4 and Figure 5.

Introduction

Hydrogen peroxide (H_2O_2), as a byproduct of metabolic processes, can be harmful to the body and damage cells if present in excessive amounts. To counteract this, the enzyme catalase catalyzes the breakdown of hydrogen peroxide (H_2O_2) into water (H_2O) and oxygen (O_2). The reaction of the enzyme catalase in catalyzing hydrogen peroxide can be written as follows:

$$2H_2O_2 \xrightarrow{\text{katalase}} 2H_2O + O_2$$

Figure 1. Catalase Enzyme Reaction with Hydrogen Peroxide (H_2O_2)

Figure 3. Theories/Concepts Added in the Catalase Enzyme Practicum Worksheet

The added theories/concepts are located at the top of the practicum worksheet. This is aimed at providing students with initial understanding of the concepts to be practiced. In the theory/concepts section, the concept of hydrogen peroxide as a product of metabolic processes that can be harmful to the body if present in excess is explained first. Then, the role of catalase enzyme as a catalyst agent capable of catalyzing hydrogen peroxide (H_2O_2) into water (H_2O) and oxygen (O_2) is elaborated. This section also includes the reaction of catalase enzyme with hydrogen peroxide. With the inclusion of theories/concepts in the practicum worksheet, students can relate these concepts to the practicum activities they perform.

Procedure

1. Place newspaper on the experimental table as a mat.
2. Label the test tubes with the letters A, B, and C.
3. Add pieces of liver to test tubes A, B, and C (each to a height of 0.5 cm in the test tube).
4. Place test tube B into a beaker containing hot water, then measure the temperature using a thermometer.
5. Place test tube C into a beaker containing cold water or ice, then measure the temperature using a thermometer.
6. Prepare a solution of H_2O_2 in test tubes I, II, and III (each to a height of 0.5 cm in the test tube).
7. Pour H_2O_2 from test tube I into the liver pieces in test tube A and immediately perform the gas bubble test using a glowing splint.
8. Repeat the same steps for test tube II with B and test tube III with C.
9. Record your observations in a table.
10. After the experiment is complete, wash the test tubes with soap

Figure 4. Practicum Procedures Before Reconstruction

Before the practicum procedure was reconstructed, it was noted that the catalase enzyme used was obtained from liver pieces placed in a reaction tube at a height of 0.5 cm (see Figure 4). This measurement was not ideal because the liver has a soft texture with varying surface thickness. Liver pieces placed in a reaction tube at a height of 0.5 cm may have different weights, making it difficult to accurately measure enzyme activity, as variations in the size and composition of the pieces can affect the reaction results (Azhar, 2016). We revised the procedure by replacing the liver pieces with liver extract (see Figure 5). The use of liver extract allows the catalase enzyme to react more easily, as it has been isolated from solid tissue, leading to faster and more measurable reactions. On the other hand, using liver pieces may take longer for the enzyme to interact with the substrate due to the barrier presented by the solid tissue (Azhar, 2016; Mohtar, 2024).

Procedure

D.1 Procedure for Liver Extract Preparation

1. Fresh liver (you can use chicken liver) is cut into small pieces and weighed at 1 gram for each treatment (normal/room temperature, hot temperature, cold temperature).
2. For the cold temperature treatment, the liver is placed in a beaker containing ice water and soaked for 10 minutes.
3. The liver pieces are placed in a mortar, and 10 mL of distilled water is added (for the cold temperature treatment, the distilled water is replaced with cold water).
4. The liver pieces and distilled water in the mortar are ground using a pestle until they become a smooth liver extract.
5. The liver extract is filtered using filter paper.

D.2 Procedure for Experiment on the Effect of Temperature on Catalase Enzyme Activity

1. Three test tubes are labeled A, B, and C.
2. 1 mL of liver extract is added to test tubes A, B, and C.
3. In test tube C, the liver extract added is the one previously soaked and ground with cold water.
4. Test tube A is placed at room temperature.
5. Test tube B is heated over a spirit burner until it reaches boiling (see Figure 2).
6. 2 mL of H_2O_2 is added to each of the test tubes A, B, and C.
7. The test tubes are immediately sealed with rubber stoppers.
8. The bubbles that appear in test tubes A, B, and C are observed, and the results are recorded in Table 3.
9. A glowing splint test is performed using a small wooden stick inserted into the test tube. The glowing splint test can be seen in Figure 3.
10. The glow of the splint is observed, and the results are recorded in Table 3.

Figure 5. Practicum Procedures After Reconstruction

Next, regarding the heating of the liver to a high temperature, we found that the procedure of placing a reaction tube containing liver extract into a beaker of hot water was ineffective and did not support the theory of catalase enzyme activity. After adding hydrogen peroxide and conducting the glowing splint test, the liver extract that had been soaked in hot water produced many bubbles, and a bright flame appeared on the glowing splint. There was no difference in the bubbles and flame when compared to the liver extract at room temperature.This finding contradicts the theory of enzyme activity, which is influenced by temperature. High temperatures can cause enzyme denaturation, so there should have been a difference in the bubbles and flame between the liver extract soaked in hot water and the extract at room temperature. This could have happened because soaking the reaction tube in hot water only heated the reaction tube, while the catalase enzyme inside remained unaffected (not denatured) and did not produce a significant reaction (Tehrani et al., 2013). The improvement to this procedure was to directly heat the reaction tube

containing liver extract over a spirit burner until it began to boil. After testing, this procedure proved effective and aligned with the theory. The bubbles produced were fewer, and the flame was dim because the catalase enzyme had been denatured due to the heat (see Figure 6).

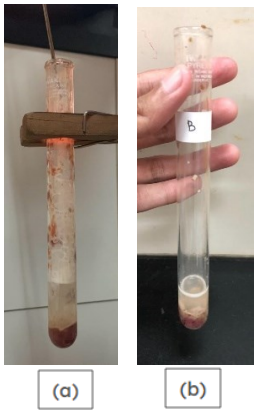

Figure 6. Practicum Results on the Effect of Heat on Catalase Enzyme Activity
(a) Liver extract treated by soaking in hot water, producing many bubbles;
(b) Liver extract treated by heating to a boil, producing few bubbles.

As for the low-temperature testing, similar to the high-temperature testing, it was found that the procedure of placing a reaction tube containing liver extract into a beaker filled with cold water was ineffective and did not support the underlying theory. The bubbles and flames produced between low temperature and room temperature did not show any difference. This could have occurred because this treatment only made the reaction tube cold, not affecting the temperature inside the reaction tube, and the catalase enzyme inside it was not affected (not inactive). The improvement made to this procedure was to soak the liver that had not been extracted in cold water (without a reaction tube) for 10 minutes, then grind it using cold water. This procedure showed better results, with fewer bubbles produced, thus supporting the theoretical basis where enzyme activity slows down at low temperatures (see Figure 7).

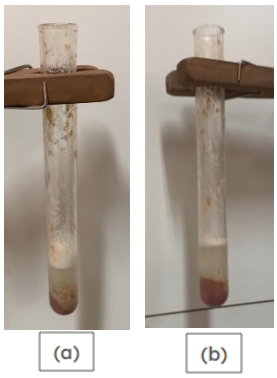

Figure 7. Practicum Results on the Effect of Cold Temperature on Catalase Enzyme Activity
(a) Liver extract treated by soaking in cold water (with reaction tube), producing many bubbles;
(b) Liver extract treated by soaking in cold water (without reaction tube) and then ground with cold water, producing few bubbles.

Based on the explanation of the reconstruction results above, it can be inferred that it is important to try out the practicum procedure before providing the practicum worksheet to students (Sari et al., 2020). Teachers should first test the practicum procedure they have created, allowing

them to anticipate any challenges students may encounter during the practicum, or whether the practicum activities can facilitate students' learning of abstract concepts. As facilitators, teachers must be able to facilitate students in reconstructing their knowledge and engage students in cognitive activities (Kurniawati, 2018).

4. CONCLUSION

The analysis of the catalase enzyme activity practicum worksheet based on Novak & Gowin's (1984) vee diagram showed the absence of underlying theories/concepts for the practicum activities. This rendered the practicum procedure less directed, and students were unable to relate the practicum activities to their underlying concepts. The reconstruction results involved adding theories/concepts to the worksheet and improving the practicum procedure to align with the theory, enabling students to analyze and construct their knowledge regarding the effect of temperature on catalase enzyme activity. This study demonstrates that the Novak & Gowin Vee Diagram can be used by biology teachers to create more effective practicum worksheets. Future research is expected to analyze and reconstruct biology practicum worksheets on other topics, particularly those susceptible to conceptual errors during practical activities.

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