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Analysis and Reconstruction of Student Worksheets on the Practicum of Catalase Enzyme, with The Tools and Materials Alternative

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Abstract

Practicum is a process to gain meaningful learning experience through hands-on and hands-on activities. Factors that cause constraints in biology practicum include incomplete tools, unavailable materials, and unavailability of practicum guides. The practicum guides circulating in schools also have various problems. Therefore, it is necessary to reconstruct the practicum guide and the existence of tools and materials that can be an alternative or solution that can overcome problems in the practicum of catalase enzyme. This research uses a qualitative descriptive method with the ANCORB flow (Analysis-Test-Reconstruction-Test). The samples used were five pieces of catalase enzyme practicum guides (LKS) from various sources with sampling techniques in purposive sampling. The analysis showed that the average LKS of catalase enzyme had a fairly good score but still needed LKS reconstruction that could measure the work of catalase enzyme quantitatively accompanied by alternative tools and materials in catalase enzyme practicum. The alternative tools that can be used are tools assembled using a syringe and a three-way stopcock. At the same time, alternative materials that can be used are water with acidic and alkaline pH, lime, lime water and clothes bleach as a substitute for hydrogen peroxide.

Keywords: *Alternative materials and equipment; Catalase Enzyme; Reconstruction; Student worksheet*

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INTRODUCTION

Biology learning consists of interaction between students and the biological objects studied, which will be more meaningful when students directly observe the biological objects studied, including objects, processes, and products (Wardyaningrum & Suyanto, 2019). One way to recognize biological objects in real life is through practicum. Practicum is an activity that aims to provide opportunities for students to test and apply the theory they have learned to certain materials. Practical activities are very important in supporting the biology learning process, emphasizing cognitive, affective and psychomotor aspects (Aliyah & Puspitasari, 2022). Biology learning cannot be separated from practicum activities because students must understand many abstract concepts in biological material. Practicum can make abstract concepts into concepts more easily captured by students (Dewi et al., 2014). Science learning accompanied by practical activities causes interaction between the domain of real objects and the domain of ideas that students have; this will lead students to identify objects and phenomena, learn facts, concepts, and causal relationships and learn theories and models that will ultimately solidify knowledge or form new knowledge (Supriatno, 2018).

The implementation of practicum in schools faces many obstacles caused by many factors. The obstacles to practicum implementation are laboratory conditions, practicum implementation time, interest in carrying out practicum, and practicum preparation and implementation (Rahmadani, 2023). The lack of tools and practicum guides also causes practicum activities not to be carried out (Lanto & Rende, 2021). Practical guides in secondary schools are also known as student worksheets (LKS) or laboratory activity designs (DKL) in secondary schools. The problems found in the LKS include (1) The objectives of the practicum emphasize more cognitive aspects than psychomotor aspects; (2) Most of them use a deductive approach with an expository model; (3) Although the practicum procedures are detailed, some of them are unstructured, and the instructions are confusing, causing multiple interpretations; and (4) The selection of material does not consider its essence, suitability, depth and complexity (Supriatno, 2013).

The practicum often implemented in universities, including in schools, is usually similar to cooking recipes (cooking recipe-based), which cannot support the development of students' thinking skills (Cahyani et al., 2021). This study found similar results in the worksheets found in student biology textbooks and practicum guides made by teachers and circulating on the internet. The worksheets found often do not include the objectives of the practicum, tools that are not available at school, expensive materials, practicum steps that do not lead to the appearance of objects or phenomena that will be studied by students and guiding questions that do not lead students in constructing new knowledge (Inayah et al., 2022). Similarly, the practicum on catalase enzyme material where diverse student observations often deviate from the expected results (Sugiarti, 2017).

Research on catalase enzyme worksheets that have been carried out includes conceptual, practical, and knowledge construction analysis along with the reconstruction of catalase enzyme practicum worksheets by (Lestari et al., 2020), analysis of the constituent components of LKS (Deratama et al., 2020), practical analysis of LKS (Setiawan et al., 2022), analysis of the constituent components of science process skills-based LKS (Sinurat et al., 2021) and reconstruction of DKL to develop HOTS (Muchsin et al., 2021). Research that has been conducted on enzyme practicum tools and materials, especially catalase enzymes, includes practicum using enzyme kit media assembled from simple tools (Seniwati, 2014), knowing the effect of pH on enzyme work by using ganong respirometers as an alternative practicum tool accompanied by alternative LKS (Inayah et al., 2022), testing the effect of substrate on enzyme action using a Ganong respirometer (Amalia et al., 2022), testing the effect of temperature on pressure bioreactors using ganong (Zulkarnaen et al., 2022), using vanish as a substitute for hydrogen peroxide accompanied by reconstruction LKS (Verawati & Supriatno, 2023). This research analyzes, reconstructs, and offers alternative tools and materials for the catalase enzyme practicum. The syringe as an alternative practicum tool has never been tested and researched in the practicum of catalase enzyme. Therefore, this study aims to analyze and reconstruct the structure of student worksheets (LKS) on the practicum of catalase enzyme and provide alternative tools and materials that can be used in carrying out the practicum of catalase enzyme.

METHOD

The method used in this research is descriptive qualitative, which aims to describe the phenomena found in the research. worksheet (LKS) samples were taken using the purposive sampling technique. As many as five pieces of Catalase Enzyme practicum guides (LKS) were prepared based on the independent and 2013 curriculum. The worksheets used include those sourced from biology books (2 pieces), the internet (2 pieces) and worksheets made by high school teachers (1 piece). The instrument used in this research is the vee diagram component analysis instrument (Novak & Gowin, 1984).

The flow of research was based on ANCORB (Analysis-Test-Reconstruction-Test). The student worksheet (LKS) analysis is a knowledge construction analysis using the vee diagram from (Novak & Gowin, 1984). The first trial was carried out by carrying out the practicum under the direction of the LKS without changing or modifying the content (tools and materials, work steps, tables of observations) of the tested LKS. Furthermore, reconstruction was carried out by changing and modifying the problematic LKS components based on the results of the trials that had been carried out. The last step is the second trial, namely conducting a trial of the LKS that has been reconstructed. All trials were carried out at the Physiology Laboratory of the Indonesia University of Education.

RESULT AND DISCUSSION

Knowledge Construction Analysis of Student Worksheet on Catalase Enzyme Practices

Analysis of the LKS knowledge construction was carried out based on the vee diagram developed by Novak & Gowin (1984), which consists of 5 diagram components. The following presents data on the presence of vee diagram components in the catalase enzyme of student worksheet (LKS) sample. Based on the analysis conducted on the student worksheet (LKS) samples, the average student worksheet (LKS) has 4 to 5 vee diagram components. The first component, the focus question, is found in all worksheet samples. The focus question serves as a direction in observing objects or events and recording data in observations. Different focus questions will lead to different objects and events to be observed (Novak & Gowin, 1984). Focus questions can be found in the practicum title, practicum objectives, or the title and practicum objectives (Ramadhayanti et al., 2020).

The catalase enzyme worksheet in this study included the objectives and the title of the practicum or one of the two. However, the worksheet should be accompanied by a focus question, not implied, to better direct students to observe objects and events. The second component, objects/events, is an object of observation or an event that can be analyzed from the results of the practicum trial by following certain procedures. All student worksheet (LKS) samples can bring up objects/events through the practicum steps taken. The third component, theory/principles/concepts, is found in all LKS samples. The existence of theory/principles/concepts on the student worksheet (LKS) was analyzed from the accompanying theoretical basis, implied in the practicum guide, contained in the practicum procedure or directed to the leading question.

Table 1. Analysis of the Existence of Vee Diagram Components on the Catalase Enzyme student worksheet (LKS)

Component Vee Diagram	Student Worksheet				
	A	B	C	D	E
Focus Question	+	+	+	+	+
Objects/Events	+	+	+	+	+
Theory/Principles/Concepts	+	+	+	+	+
Record/Transformation	+	+	+	+	+
Knowledge Claim	+	+	-	+	+

The fourth component, namely data recording/data transformation (record/transformation), is found in all samples of student worksheet (LKS). The purpose of data recording transformation is for students to organize observations in a form that allows them to develop answers to the focus question. Students should discuss the suggested table formats and decide which format best organizes the observations to answer the focus question (Novak & Gowin, 1984). The existence of notes/transformation on the student worksheet (LKS) is analyzed based on the direction in which data is recorded in the work steps, and it can be accompanied by instructions to change the form of data (transformation). Data recording on the student worksheet (LKS) sample is only in the form of instructions, or a table is provided as a guide for recording data; data transformation on the student worksheet (LKS) sample is in the form of directions to change data from sentence form to certain numbers. Data transformation should direct students to transform certain data into graphs and diagrams to train students' quantitative skills (Supriatno, 2013).

The fifth component, knowledge claim, is found in 4 samples of student worksheet (LKS) and not in 1 sample of LKS. This component can be analyzed from the presence of leading questions that direct students in constructing knowledge from factual to conceptual or directions to conclude based on the data that has been obtained. The basis of knowledge claims is data recording and transformation. Knowledge claims can provide evidence to students that building knowledge requires the application of previously known concepts and principles, understanding that constructing new knowledge allows students to change and or expand the meaning of concepts or principles that are already known and see new relationships between them (Novak & Gowin, 1984). The existence of the vee diagram component in the student worksheet (LKS) has a difference in quality between one student worksheet and others. The following presents the score achievements of each vee diagram component on the catalase enzyme worksheet.

Table 2. Analysis of Vee Diagram Component Scoring on the Catalase Enzyme student worksheet (LKS)

Worksheet Code	Diagram Vee Component					Total Score
	Focus Question	Objects/ Events	Theory/ Principles /Concepts	Record/ Transformation	Knowledge Claim	
Maximum Score	**3**	**3**	**4**	**4**	**4**	**18**
A	2	3	2	2	2	11
B	2	3	2	2	2	11
C	2	3	2	2	0	9
D	1	2	2	2	3	10
E	2	3	3	2	3	13
Average Score	2,25	2,8	2,2	2	2	10,8

The focus question component has an average score of 2.25 out of a maximum score of 3. These results align with research (Deratama et al., 2020) that the problem to be studied (focus question) is implied in the objectives or other components in the LKPD and explicit in the problem formulation. All samples of student worksheet (LKS) have focus questions that lead to the acquisition of data/concepts, but some focus questions are still confusing, so they cannot produce appropriate data. The second component, namely objects and events, has a score of 2.8 out of a maximum score of 3. Objects or events in the student worksheet (LKS) sample can all be identified and are consistent with the focus questions. The third component, theory/principle/concept, has an average score of 2.2 out of a maximum score of 4. The catalase enzyme LKS sample contains relevant concepts and is accompanied by one of the conceptual and procedural principles; this component does not get maximum points because only concepts with one procedure are identified. No theory is identified on the worksheet. Some concepts are built with leading questions on the worksheet, but there are also leading questions that only ask for facts, so they cannot construct concepts. There are also concepts on the LKS that can also be learned not through practicum but through literature studies.

The fourth component, data recording/transformation, has an average score of 2 out of a maximum score of 4. Most worksheets do not contain data transformation but only qualitative data recording. This finding aligns with the research results (Astika et al., 2020) that most catalase enzyme worksheets do not contain identifiable records or transformations. The fifth component of the vee diagram component is knowledge claims, with an average score of 2 out of a maximum score of 4. Knowledge claims on the LKS sample include concepts that can be generalised, and some knowledge claims are consistent with data recording. However, knowledge claims are not in line with the recorded observation data, and even one LKS sample does not contain knowledge claims. Knowledge claims result from the interaction of students' prior knowledge with objects/events observed by students in practical activities (Novak & Gowin, 1984). The quality of objects/events strongly influences the students' observation in practical activities (Ramadhayanti et al., 2020). The LKS should be able to direct students to construct knowledge through interactions between students' prior knowledge and quality objects and events obtained through practicum activities so that good and quality knowledge claims are produced.

Table 3. Results of the Work Step Trial on the Catalase Enzyme LKS

Problematic work step instructions	Problem description of work step test results
Grind the chicken liver mixed with distilled water using a mortar and pestle.	Pureeing chicken liver takes a long time (10-15 minutes). There is no specific guidance on the amount of distilled water to be mixed with the mashed chicken liver, which is inefficient as students continuously add distilled water to the mashed liver.
Strain the above mixture into a measuring cup.	This step was not feasible as the filter paper could not filter the liver extract. The volume of distilled water was increased to 30 ml, but the liver extract could not be filtered. This step will only make it difficult for students to complete the practicum.
Add ten drops of HCl solution (lime juice) to tube A and measure the pH with pH paper.	Measurement with pH paper is difficult because the test tube has a narrow mouth, and the height of the solution is only about 2 cm. As a result, the researcher must tilt the tube and put his hand into it to measure the pH. This is dangerous if the solution in the tilted tube spills or the HCl solution gets on the student's hand. The pH measurement event did not appear in the data recording (not needed).
Add ten drops of NaOH solution (baking soda powder) to tube b and measure the pH with pH paper.	There is no specification of the HCl solution that must be used in the practicum. The tool (drop pipette) for dripping NaOH solution is also not included in the list of practicum tools. There is no warning about the dangers of NaOH solution. It is difficult to measure pH for the same reason as the HCl solution. The pH measurement event does not appear in the data recording (it is not required).
Write your observations in the table below. (There are directions for writing down the flame test results).	No procedure can cause a flame event.

Results of Work Step Trial of Catalase Enzyme Laboratory Activity Design

The trial of work steps was carried out without changing or modifying the student worksheet (LKS) components; the trial was carried out per the instructions in the LKS. The effectiveness of practicum work can be measured in terms of practicum procedures related to what students do and practicum results in the form of what students learn (Millar, 2004). The effectiveness of the practicum procedure in question is the implementation of the procedures/work steps in the student worksheet, which can also produce the expected data/facts. The results of the research (Deratama et al., 2020) stated that there were still problems with the work steps contained in the catalase enzyme worksheet at the high school level. As many as 60% of the LKS do not have the right tasks with unstructured and systematic work steps that confuse students (Lestari et al., 2020). The selection of inappropriate and inappropriate work-step instruction sentences causes confusing sentence meanings that make it difficult for students (Wahidah et al., 2018). The trial work steps carried out on the LKS are presented in the following table.

Alternative Tools and Materials for Catalase Enzyme Student Worksheet

Tools that are often used in the implementation of catalase enzyme practicum include test tube racks, test tubes, mortars and pestles, drop pipettes, sticks and matches, test tube clamps, knives, cutting boards, spatulas, spirit lamps, three legs, filter paper, digital tubes, pH paper and thermometers. The tools often used to implement catalase enzyme practicum include HCL, NaOH, KOH, chicken liver, ice cubes, Aquades and H2O2 (hydrogen peroxide). Hydrogen peroxide can be found in bleach and disinfectants (Ridarsyah et al., 2015), so using hydrogen peroxide in catalase enzyme practicum can be replaced with a bleaching liquid and vanish.

Table 4. Alternative Materials in Catalase Enzyme Practicum

Initial Practicum Materials	Alternative Materials
HCL	1. Lime 2. Water with acidic pH Suggestion: Kangen water acidic pH
NaOH/KOH	1. Lime water 2. Water with alkaline pH Suggestion: Kangen water with alkaline pH
H_2O_2 (hydrogen peroxide)	Clothes whitener with hydrogen peroxide as the main active ingredient. Suggestion: Vanish (clothes bleach)

Some essential tools and materials for practicum are difficult to find, expensive or less efficient and effective in facilitating the practicum of catalase enzymes. The test tube used to react the catalase enzyme with H_2O_2 is less effective because it can only measure qualitatively with the results obtained limited to data on the number of bubbles and embers (Inayah et al., 2022). Many test tubes are also needed if the practicum is carried out by one class, usually filled with more than 20 students. Researchers also found that using mortar and pestle was ineffective in smoothing chicken liver because it took a relatively long time. The causes of non-implementation of practicum are incomplete sets of tools, damaged tools and unavailability of materials (Lestari et al., 2017). The following presents alternative materials that are relatively easy to obtain and have low prices when carrying out the practicum of catalase enzymes.

An alternative tool that can be used to measure the work of enzymes quantitatively is easy to use and maintain and can be purchased at a relatively low price. It is a tool assembled using a 60 ml syringe (2 pieces), 12 ml syringe (1 piece), three-way stopcock (1 piece), and a small transparent hose measuring 3 cm (1 piece). The tools are then assembled into a new tool with the following steps: 1) Connect the 60 ml syringe with a small transparent 3 cm hose and then connect it to the largest hole of the three-way stopcock. 2) Connect the remaining 60 ml syringe to the side of the three-way stopcock parallel to the previously installed syringe. 3) Connect the 12 ml syringe to the remaining three-way stopcock hole. The assembled device is presented in Figure 1.

The 60 ml syringe connected to a small transparent hose measuring 3 cm is used as a place for the chicken liver with certain treatments (acidic or alkaline pH); the remaining 60 ml syringe is used to measure the volume of oxygen formed due to the reaction of the catalase enzyme with hydrogen peroxide, 12 ml syringe is filled with hydrogen peroxide which will be injected into a 60 ml syringe containing chicken liver. At the same time, the three-way stopcock functions as a connection between the three syringes and as a tool that can regulate the occurrence of the catalase enzyme reaction and the transfer of oxygen so that the volume of oxygen formed can be measured.

Figure 1. Catalase Enzyme Practicum Tool Alternative
Source: (Author's Document)

Reconstruction of Student Worksheets on Catalase Enzyme Practicum

The following is presented the reconstruction of the LKS carried out using alternative tools and materials on the practicum of catalase enzyme.

How does pH affect the action of catalase enzyme?

1. Practicum Objective:
   Students are able to analyze the factors that affect enzyme action.
2. Time Allocation:
   2JP x 45 minutes
3. Equipment and Materials

Materials:
1. 20 ml Kangen water pH 2.5
2. 20 ml Kangen water pH 5

Notes: Ingredients 1 and 2 can be replaced with 1 lime.

3. 20 ml Kangen water pH 7 / 20 ml tap water
4. 20 ml Kangen water pH 9.5 /Lime water 20 ml
5. 1 pack Vanish 60 ml
6. 10 grams Chicken liver
7. 8 sheets of pH paper
8. 4 sticks

Equipment:
1. 60 ml syringes (2 pieces)
2. 12 ml syringe (1 piece)
3. Three-way stopcock (1 piece)
4. 3 cm transparent small hose (1 piece)
5. Drip pipette (4 pieces)
6. Match (1 piece)

Attention!

Be careful when injecting or mixing vanish as hydrogen peroxide with chicken liver + treatment with a certain pH. Mixing (injection) should not be done strongly and spontaneously because it can cause the plunger of the syringe to be thrown strongly; mixing should be done gradually and slowly. Do not increase the level of ingredients beyond that specified in the work step. It is better to pay more attention to the three-way stopcock so that it can be known whether it is closed or open.

4. Work Steps:

Description: 60 ml syringe as syringe A and syringe B, 12 ml syringe as syringe C.

1) Connect the small transparent hose to the largest hole of the three-way stopcock.
2) Connect the hose with syringe A.
3) Put 2 ml of crushed chicken liver into syringe A.
4) Add kangen water with a pH of 2.5, as much as 2 ml, into syringe A, and then measure the pH using pH paper.
5) Close syringe A with the syringe plunger.
6) Connect syringe C with a three-way stopcock in the opposite direction (forming an angle of 900) with syringe A.
7) Insert vanish as much as 2 ml into syringe C and then close it with the syringe plunger.
8) Position the plunger of syringe B at the 0 ml point and then connect syringe B to the remaining three-way stopcock hole in a position parallel to syringe A.
9) Position the three-way stopcock of syringe A and syringe C open and inject the vanish solution into syringe A slowly and gradually (2-3 times).
10) Position the three-way stopcock on syringes B and A in the open state. Caution: Do not press and touch the plunger of syringes B and A.
11) Observe and record the changes that occur in syringe A.

12) Observe and record how many ml the syringe B plunger moves from the 0 ml position.
13) Close the three-way stopcock of syringe B, then open the plunger and insert the embers into syringe B.
14) Observe and record whether there is a flame.
15) Repeat the same steps for kangen water pH 5, 7, and 9.5.

5. Observation Table:

No	Treatment	pH	Volume of Bubbles (ml)	Flame
1.	Chicken liver + Kangen water pH 2.5 + Vanish			
2.	Chicken liver + Kangen water pH 5 + Vanish			
3.	Chicken liver + Kangen water pH 7 + Vanish			
4.	Chicken liver + Kangen water pH 9 + Vanish			

Description : (+) = There is a flame; (-) = No flame

6. Questions:
1) Which treatment produces bubbles/gas and which does not produce bubbles/gas?
2) What causes the formation of bubbles/gas?
3) What gases were formed as a result of the experiment?
4) Was there a flame in the experiment? If there is a flame, why do you think the fire can burn?
5) In which treatment did you find the bubbles/gas with the most volume and the least volume?
6) What conclusions can you formulate regarding the effect of pH on the work of the catalase enzyme?
7) Make a bar graph of the volume change from the experiment you have done!
8) What questions do you have about the factors that affect enzyme action after doing this lab?

CONCLUSION

Analysis of the LKS knowledge construction based on the presence of vee diagram components shows that the focus question, object/event, theory/principle/concept and data recording are owned by all LKS samples. In contrast, one LKS does not own the knowledge claim component. The average LKS has a fairly good score. However, it is still necessary to reconstruct LKS that can measure the work of the catalase enzyme quantitatively, accompanied by alternative tools and materials that can solve various problems in implementing the catalase enzyme practicum. The alternative tools that can be used are tools assembled using a syringe and a three-way stopcock. Alternative materials that can be used are water with acidic and alkaline pH, lime, lime water and clothes bleach as a substitute for hydrogen peroxide.

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