The development of an enzyme catalase kit for engineering students at technical-vocational schools

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The development of an enzyme catalase kit for engineering students at technical-vocational schools

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ABSTRACT: This study aims to develop an enzyme catalase kit (ECK) for engineering students at a technical-vocational school in Makassar. The goals of the ECK are: 1) to identify the sources of the enzyme catalase contained in the environment; 2) to test the effect of temperature of the activity of the enzyme catalase; and 3) to test the effect of pH on the activity of the enzyme catalase. The engineering students mostly focus their academic efforts on mechanical, electrical or computer engineering. However, some technical-vocational schools still require students to learn some basic natural sciences. An additional learning kit is necessary to deliver the natural sciences subjects to these engineering students. The development process of the ECK was done by using ADDIE models. This research was conducted in a technical-vocational school laboratory from March to August 2016. The researchers assigned two experts to rate the quality of the kit. The result indicated that the enzyme catalase kit was valid, practical and effective for the engineering students.

Keywords: Enzyme catalase kit, engineering students, technical-vocational school

INTRODUCTION

An enzyme catalase kit (ECK) is a learning medium, which has been developed with the aim of identifying natural materials used as the catalase enzyme source and environmental factors (temperature and pH) in catalase enzyme activities. The (ECK) has been considered valid, practical and effective to use as a learning medium, especially in the learning of natural science, chemistry and biology for students. In addition, it has potential to enhance the students' inquiry abilities. The (ECK) kit is the manifestation of technology implementation in the learning of sciences.

The science itself is a method to learn systematically about nature. The learning of science is not only memorising the concepts or terms, but also further comprehending the concepts. Both objectives can be attained by doing meaningful learning. According to Dahar [1] and Sochibin, et al [2], meaningful learning is a process of linking new information of relevant concepts in one's cognitive structures.

The enzyme catalase kit has potential in enhancing inquiry ability of students. The improvement in students' ability can be acquired through the application of several basic skills, such as observing, inferring, predicting, classifying, asking and communicating [3]. In addition, several advanced process skills also play a significant role in formulating problems, identifying variables and experimenting in learning. These kinds of skills are at the basis of activities that have the potential to develop students' inquiry abilities of students [4].

The inquiry learning strategy is a sequence of learning activities that place emphasis on critical and analytical learning processes to find the answer to a problem [5]. Besides that, learning is an activity, which maximally involves all student abilities to inquire about things (object, human or event) systematically, critically, logically and analytically, with the aim of formulating the findings. The inquiry learning strategy is mainly concerned

> *…with students learning a generalized method of problem solving. That method would include sensing a problem, articulating it, hypothesizing a plausible solution, gathering data, testing hypothesis and drawing appropriate conclusions* [6].

The implementation of inquiry learning is based on the principles of constructivism learning. The application of the theory of constructivism in education can be done by: a) using the constructivist approach; b) facilitating students to

learn; c) considering the knowledge and the level of thinking of students; d) applying continuous assessment; and e) enhancing the intellectual ability of students, and setting the classroom as a space of exploration and discovery [7]. According to constructivist theory, learning is more effective when teachers use constructivist methods mainly focusing on the activity of learning and the student experience, centring on interactions among students, and students and teachers, and working with concrete materials in solving realistic problems [8-10].

Therefore, there are several learning principles, which should be considered: a) orienting intellectual development; b) the interaction principle; c) the asking principle; d) the learning to think principle; and e) the openness principle. The syntaxes of the learning process are: a) orienting; b) formulating problem; c) hypothesising solution; d) gathering data; e) testing hypotheses; and f) drawing conclusions. These principles were in-line with previous findings [11] and the adult learning principles assist in transforming an expert into an educator [12]. These principles and steps will be easy to implement, if in the implementation of learning, the teacher uses tools/learning media. In this regard, one of the media is the ECK in which the learning topics are related to the enzymes. In the technical-vocational schools, the construction of the kit will provide additional assistance to both the teachers and students as they utilise the kit as a learning tool or medium.

METHOD

The development of the ECK refers to the analysis, design, development, implementation and evaluation (ADDIE) development model. The model consists of five stages included in its name. The validity of the medium was assessed by two experts using a set of validity instruments. The experts applied the assessment according to Hobri [13]. The practicality and effectiveness of the kit was tested when the kit was used in a laboratory setting. The practicality was tested based on the ease of implementation of the trial, and the effectiveness was assessed based on the achievement of the objectives in the experiment stage.

RESULTS AND DISCUSSION

Kit Development Results

The objectives of the present research are: 1) identifying the catalase sources; 2) examining the effect of temperature on the enzyme catalase activity; and 3) examining the effect of pH on the catalase enzyme activity. Experimental tools were developed to achieve the objectives as shown in Figure 1.

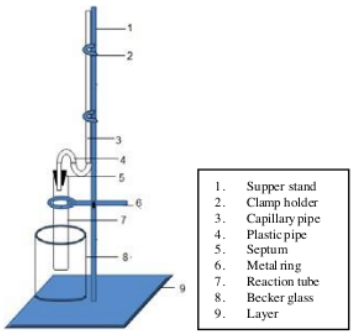

Figure 1: Tool design for a catalase enzyme test (Prototype 1).

Then, Prototype 1 of the enzyme catalase kit was improved by considering the comments and critics from the validators. The improved model produced a Prototype 2 of the kit that can be seen in Figure 2.

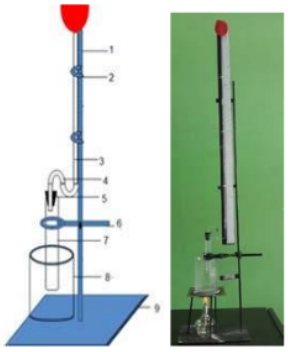

Figure 2: Improved model of the kit (Prototype 2).

Validation Results

The results of the validity test by the experts are shown in Table 1. The results showed that the validity score of the kit was 4.45, which indicated that the ECK performed as expected based on the validity criteria.

Table 1: Validity of the enzyme catalase kit.

No.	Validity criteria	E1	E2	*M*
1	Connection with the topics	4.67	4.33	4.83
2	Educational aspect	5.00	5.00	5.00
3	Tool durability	4.00	3.67	3.83
4	Practicality of tool development	4.20	4.60	4.40
5	Tool safety	4.50	4.50	4.50
6	Tool development value	4.50	4.00	4.25
			VS	4.45

Note: E= expert, *M*= mean score, VS= validity score (Σ*M*/6= VS)

Moreover, both teachers and students need to further understand the operation of the kit, and for this purpose, a manual for the kit was also developed. The validity score yielded 4.52, this score indicating that the manual met the minimum standard of a valid manual. The validity test scores of the manual is shown in Table 2.

Table 2: Validity of the manual enzyme kit.

No.	Aspects	E1	E2	*M*
1	Content	4.80	4.40	4.60
2	Language	4.20	4.20	4.20
3	Layout	4.69	4.80	4.70
4	Learning	4.75	4.75	4.75
			VS	4.52

Note: E = expert, *M* = mean score, VS = validity score (Σ*M*/6 = VS)

In addition to the quantitative data, the observation of the use of the enzyme catalase kit in a laboratory setting is shown in the tool practicality table (Table 3). The practicality tool was examined based on several aspects, i.e. tool usage, source availability, experiment steps and skill process. Based on the observations, it obtained the tool practicality score of 4.49, which was indicated as practical for teachers and students.

Table 3: Practicality of the enzyme catalase kit.

No.	Aspects	E1	E2	*M*
1	The usage of the tool	4.83	4.33	4.58
2	Source availability	4.67	4.00	4.33
3	Experiment stages	4.40	4.60	4.50
4	Process skill	4.44	4.67	4.56
			VS	4.49

Note: E = expert, *M* = mean score, VS = validity score (Σ*M*/6 = VS)

The effectiveness of the tool usage was observed from the achievement of the objectives during the experiment. The four materials contained catalase enzymes can be seen in Table 4. From the materials tested, catalase enzymes are mostly found in chicken liver.

Table 4: Ingredients of catalase enzymes on various materials.

Material	Catalase enzymes existence	Fire status
Chicken liver	Yes	+++
Sprout	Yes	++
Corn	Yes	++
Jicama	Yes	+

Note: - none, + low; ++ average; +++ high

DISCUSSION

The development of the enzyme catalase kit for engineering students at a vocational-technical school has brought new understanding, as well as a strategy in teaching sciences to engineering students. The students who are actively involved in a mechanical or technical speciality may find learning sciences (e.g. chemistry and biology) less clear. Nevertheless, providing the students with more observable tool and materials potentially improves their understanding. For this reason,

the development of the ECK provides additional information for educators in teaching sciences to vocational-technical students.

During the development of the ECK, the validator considered that the design of the kit in Prototype 1 (Figure 1) should be refined for the following reasons, i.e. 1) calculating the speed of reaction requires a scale; 2) the pipe is considerably short, because when using concentrations of enzyme and high substrate, the indicator movement is very fast and overflowed from the capillary tube; 3) the amount of oxygen produced is difficult to measure roughly as it loses at the end of the capillary tube; 4) the process must be done quickly, implying low accuracy; and 5) testing qualitative presence of oxygen should be done immediately before the oxygen is released into the air.

Based on the results of validation analysis, the developed enzyme kit has been changed. The changes which were made involve the end of the capillary tube that is connected to a rubber balloon. This change was made in order that when the oxygen gas produced cannot be separated at the end of the capillary tube, it remains in the balloon where a chemical reaction occurs. The consequences of these changes are: a) the O_2 gas produced cannot be separated from the capillary tube; b) the measurement of oxygen, which is roughly produced by calculating the volume of the balloon is easily applied; c) qualitative test of the oxygen presence as a result of the decomposition of H_2O_2 can be properly applied, because the process is not rashly done (Figure 2). Based on these changes, the catalase enzyme kit is considerably valid, as shown in Table 1.

Catalase enzyme is a type of enzyme, which is able to break carbon and carbon-nitrogen bonds. It is so named as the desmolase enzyme. In the plant, it is produced by the peroxisomes organelles. Therefore, the isolation of catalase enzyme in plants is mostly done by taking the stem or leaves that have grown and have peroxisomes. In animals, catalase enzyme can be isolated from the liver (hepatic). Catalase enzyme is able to perform the oxidation of toxic materials in the cell. An example of dangerous compound is hydrogen peroxide (H_2O_2). Peroxide compound must be decomposed into harmless water (H_2O). Catalase enzyme accelerates the decomposition reaction of hydrogen peroxide (H_2O_2) into water (H_2O) and oxygen (O_2). Decomposition of hydrogen peroxide (H_2O_2) is characterised by the occurrence of bubbles [14]. The latest reaction is used as a barrier to prevent the accumulation of H_2O_2. The notable thing is the nature of highly permeable microbody membrane, which can make inorganic ions with low weight molecular compounds and the size of the sucrose may move freely into microbody [15].

CONCLUSIONS

Based on the findings, it can be concluded that the enzyme catalase kit was valid, practical and effective for students in technical-vocational schools. Future study is still necessary to fully grasp the practicality and the effectiveness of the enzyme kit. The enzyme catalase kit assists technical-vocational school students in understanding the natural sciences. In addition, the use of this kit enriches the students' learning experience, particularly in understanding science.

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BIOGRAPHIES

Muharram is a Professor of Chemistry at Universitas Negeri Makassar. He received his Bachelor degree in Chemistry Education from IKIP Ujungpandang in 1987, his Magister of Chemistry Science from ITB Bandung in 1993 and his Doctor rerum naturalium in organic chemistry was obtained from Otto von Guericke Universitaet Magderburg Germany in 2004. He has more than 50 publications on pure chemistry and chemical education, such as 1) Efficient Synthesis of Optically Active R - and S-2-Phenylpropanal. *PublScie-AEIF of Journal*; 2) Stereosectivity of Aldolreaction in C1-C12 Epothilone Sythesis. *J. Matematika & Sains*; and 3) The Antibacterial Properties of Bayur Tissues' Extract (Pterospermum subpeltatum C.B. Rob). *J. Teknologi*. He contributes his knowledge to many scientific conferences and publications.

Adnan is a Professor of Biology Education at Universitas Negeri Makassar. He has conducted a number of studies in the area of biology and education. He completed his Bachelor of Biology Education and doctoral degree in biology education at Universitas Negeri Makassar. He also completed his Master's in biology from Institut Teknologi Bandung. He desires to contribute more to both biology as a science and the teaching of biology (biology education). He has led a number of research topics in developing learning model and strategies for teaching biology at school.

Sudding is a Professor of Biochemistry at Universitas Negeri Makassar. He completed his Master and doctoral degree in biochemistry at Institut Teknologi Bandung. He received his Bachelor of Chemistry Education from Universitas Negeri Makassar. He is a well-known professor in the area of biochemistry at Universitas Negeri Makassar. He is committed to developing various learning and teaching strategies in teaching and learning chemistry. His research interest focuses on biochemistry and biochemistry education.

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