Contribution of Metacognition Awareness, Science Process Skills and Vee Diagram in Designing Experiment

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Abstract. This study explores the contribution of metacognition awareness, science process skills, and Vee Diagrams in predicting the experimental design abilities. The statistical population involved students of the third semester Department of Biology Education at Kuningan University. From these, 28 students were selected as samples through purposive sampling. Based on the nature of the subject and the research question, the correlation method was considered the most suitable for this study. Vee Diagram assessment rubric, MAI questionnaire, and Science Process Skills test were used to collect data. For data analysis, Pearson correlation and multiple regression were used. The results showed that metacognition awareness, science process skills, and Vee Diagrams contributed significantly to designing experiments with an R-value of 0,998. Among the components of metacognitive awareness, science process skills and the Vee Diagram were -0.537, -0.742, and 1.948, respectively.

Keywords: Metacognition; Science Process; Vee Diagrams

1 Introduction

One of the applications of the nature of science in science education is in the form of practicum or experiment. Practicum is an integral part of biology education and plays an essential role in achieving the goals of biology education. However, practicum implementation in biology learning, especially in Biochemistry, emphasizes the procedural and structured aspects. Practicum implementation in which each stage was guided like a cookbook intends to utilize mastery of concepts to forget other goals. A practicum performance like this tends only to clarify concepts learned by students[1]. Students are not allowed to develop laboratory activities to understand the concepts obtained is not optimal. It causes a separation between the acquisition of theory and practical activities in the laboratory. Several ways can be done to change traditional experiments in obtaining different objectives so that they are far from the following recipes[2]. Students who only follow practicum procedures which are still cookbooks, result in their science process skills not developing optimally even though they often do the practicum. Students are not trained in formulating problems or designing experiments to answer problems in practicum[3].

Scientific inquiry-based practice can be done, and then students can apply and improve science process skills in the Biochemistry practicum. Determining tools and materials, designing experiments, observing, interpreting data, and submitting new hypotheses related to the subject was part of the science process skills that can be developed in designing

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experiments[4]. Vee diagrams are a metacognition tool used to guide laboratory work and facilitate learning and reflective thinking as planned and done in scientific investigations [5]. Vee Diagram helps students in the thinking process by acting as a metacognition tool that requires them to make explicit connections between previously learned information and newly acquired information through scientific inquiry[6]. Students can organize their thinking processes and develop science process skills through investigation activities to seek truth or knowledge through scientific processes that are part of the science process skills. Science learning is a goal-oriented process to deliver students to mastering science process skills, basic skills, and integrated skills. This Vee diagram is a diagram that is formed through a process of scientific inquiry in a laboratory where the science process skills were integrated into it. The application of Vee diagrams in designing experiments in the Biochemistry class is expected to develop metacognitive awareness and student science process skills. It follows the *Learning Outcomes* Department of Biology Education, where the ability to design experiments was one of biology education students' competencies. The purpose of this study was to determine the contribution of metacognition awareness, science process skills, and Vee Diagrams to predict the ability of design experiments.

2 Methodology

Based on the nature of the subject and the research question, the correlation method was considered the most suitable for this study. There are two correlational research variables: the independent and dependent variables. The independent variable in this study is Vee Diagram (X1), Science Process Skill (X2), and metacognition awareness (X3), while the dependent variable is the ability to design experiments. The statistical population involved students of the third semester Department of Biology Education at the University of Kuningan for the 2017-2018 academic year. From these, 28 students were selected as samples through purposive sampling. Vee Diagram assessment rubric, MAI questionnaire, and Science Process Skills test were used to collect data. The Vee Diagram assessment rubric consists of 5 categories adapted by Novak and Gowin[5], the MAI questionnaire used was developed by Schraw and Dennison[7], and Science Process Skill Test content validity was reported to be acceptable. This research instrument was distributed among participants, and gathered data were analyzed using Pearson correlation and multiple regression. Pearson Correlation was used to determine whether there is a correlation between vee diagram, science process skills, and metacognitive awareness towards the ability to design experiments. Meanwhile, multiple linear regression was used to predict the variable's ability to design experiments (vee diagram, science process skills, and metacognitive awareness).

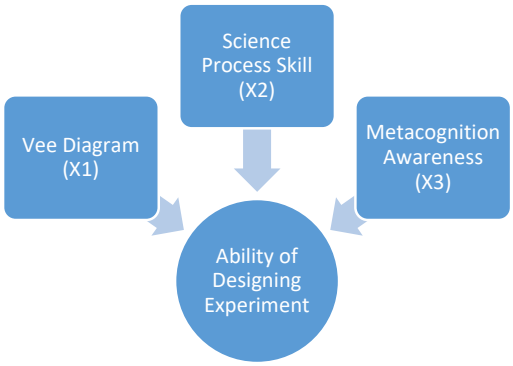

Figure 1. Research Design

3 Result and Discussion

The three variables of metacognition awareness, science process skills, and vee diagrams contribute to the ability to design experiments. The amount of this contribution is presented in table 1 below.

Table 1. Correlation of Variables with the Ability to Design Experiments

Variable	Correlation
Vee Diagram	0, 892
Metacognition Awareness	0, 573
Science Skills Process	0, 588

The variable that contributed the most to the ability to design experiments was the Vee Diagram, while the variable that contributed the least was metacognitive awareness.

Table 2. The independent variable regression model of the ability to design experiments

Model		Sum of Square	df	Mean Square	F	Sig
3	Regression	5410,061	3	1803,354	1687,117	<0,05
	Residual	25,654	24	1,069		
	Total	5435,714	27			

The linear model between vee diagram, science process skills, and metacognition awareness with the ability of design experiments shows the significance of the regression equation F = 1687,117 with significance < 0.05 (Table 2). These indicate that the regression models of the three independent variables can predict design experiments' ability with an R-value of 0,998 and adjusted R is 0,995.

Table 3. The independent variable regression coefficient model of the ability to design experiments.

Model		Unstandardized Coefficient		Standardized Coefficient	t	Sig
		B	Std. Error	Beta		
3	(Constant)	-21,996	1,456		-15,425	<0,005
	Vee Diagram	2,916	0,054	1,948	53,989	<0,005
	Science Process Skill	-0,995	0,036	-0,742	-27,296	<0,05
	Metacognitiom Awareness	-0,655	0,029	-0,537	-22,455	<0,05

The third regression model can be used to create a regression equation that describes the relationship of the three independent variables (vee diagram, science process skills, and metacognition awareness) to the dependent variable (ability to design experiment) as presented in Table 3. These results indicate that the equation Y = -21,996 + 2,916X1 - 0,995X2 - 0,655X3 can predict the dependent variable.

The result reveals that Vee Diagram, science process skills, and metacognition awareness can predict the ability of design experiments. The Vee Diagram has the most significant correlation with the ability to design experiments because the process carried out by students in designing experiments is guided by the stages contained in the Vee Diagram. The Vee diagram serves as "thinking" and "doing" [5], [8]. The application of Vee diagrams begins with writing conceptual knowledge, which is the student's initial knowledge on the left side of "V," and writing the experimental procedure to answer the problem on the right side. The starting point of the process is a focus question in the middle of the diagram. Focus questions are an active dynamic bridge between known knowledge and estimates derived from the action. Methodological knowledge described as "doing" is placed on the right-side diagram. When students carry out activities to answer focus questions, they record data during the action and turn it into tables, graphs, etc. Then they write knowledge claims and experiments about the step [9]-[11]. Using Vee Diagrams to design experiments can develop student potential in cognitive, affective, and psychomotor aspects; besides, the implementation of practicum will further develop the nature of science where the values in science can help shape student character[1]. Vee diagrams would still be a valuable context for an explicit reflective approach for functional understandings of the nature of science and scientific inquiry by combining the historical case study with procedural ideas in the laboratory investigations[12].

During designing experiments, with the help of the Vee Diagram, students are allowed to develop procedures, conduct experiments, and come up with ideas to build their knowledge. The experimental design begins with identifying the problem as outlined in the form of a focus question, proposing hypotheses, determining variables, determining tools and materials, and determining work procedures. This process is then continued by conducting experiments whose results are described on the methodological side in notes, data transformation, conclusions, and value claims. This process is a stage for developing science process skills. Therefore, process skills also contribute to the ability to design experiments.

Vee Diagram structure is a diagram equipped with many labels and systematic manual guidelines for students to make reasoning based on the problem context using scientific methods such as formulating hypotheses, submitting variables, and conducting experiments [13]. The stages of the scientific method on the Vee Diagram are part of the science process

skills. Students' experimental designs in Vee Diagrams accommodate students' science process skills such as formulating hypotheses, asking questions and planning experiments as outlined in the Vee Diagram on the conceptual side. This skill is developed before students carry out practical work. After the experimental design was applied in practicum implementation, the science process skills developed were observing, grouping, interpreting, predicting, applying concepts, communicating, and using tools and materials. Vee Diagram is preferably used to prepare an experiment report, bridging theory and practice and providing analytical views [4]. Vee Diagram is an effective learning technique for developing the science process skills and can provide benefits for the main foundation of science education, one of which is the science process skills [14]. Science process skills need to be developed through direct experience as a learning experience to appreciate better the process or activity undertaken[15]. One form of direct experience in the learning process is designing an experiment, where the stages in designing an experiment are part of science process skills. Therefore, science process skills need to be trained and developed in science learning because science process skills have crucial roles. One of them is to help students develop their minds and help students learn science concepts[16].

Although it slightly correlates with the ability to design experiments, metacognitive awareness also contributes to developing the ability to design experiments. The process carried out by students in designing experiments is a process or activity that is included in metacognitive behaviour. The experimental design made by students was carried out in groups, where members of each group contributed to designing the experiment, starting from determining the focus of the question, proposing hypotheses, planning work procedures, and tools and materials to finally take the experiment. Metacognition awareness that can arise at these stages is evaluating the reasoning of other group members, evaluating their understanding abilities, evaluating their plans, and evaluating laboratory work procedures [17]. The practicum, which begins with designing experiments, allows students to control what they do in the laboratory thoroughly. Students are asked to plan their methods, take experimental data, and draw conclusions. It is where metacognition awareness plays a role in supporting students' ability to design experiments in planning, monitoring, and reflecting on cognitive learning strategies to interact with their groups and reflect on the experiments they develop. This process helps students control their learning process and become independent learners by planning, monitoring, and evaluating their learning process [18].

Developing metacognitive awareness of students can develop science process skills in terms of identifying variables, designing experiments, and other operational skills that are more compared to practicum in a structured manner like a recipe book[19]. Metacognition awareness can have a positive effect because, in the experiment, students discuss each step of the experiment with other group members, ask questions about problems related to practicum topics and get feedback from the implementation of experiments. It is not surprising that students develop their science process skills in identifying variables and designing experiments which are part of science process skills. Students can build observing skills, submit hypotheses, interpret data in graphs. This explains that designing and conducting experiments allows students to develop their science process skills. If students are accustomed to developing metacognitive awareness about the goals and benefits of their strategies, they will likely be able to generalize these strategies to new situations. Metacognition awareness can develop science process skills and students' understanding of science concepts to produce a better understanding of concepts and science process skills[20].

The ability of metacognition helps students understand how to acquire knowledge. A student who can solve problems explained how he obtained solutions to these

problems. Students can describe the correlation between conceptual and methodology to answer the problems. Metacognition awareness can help students solve problems through effective design, which involves identifying problems, understanding problems that need to be solved, and understanding practical strategies [21]. This, of course, needs to be accommodated by applying laboratory learning in the form of designing experiments. This metacognition awareness is accommodated through metacognition tools or devices, namely the Vee Diagram. Vee Diagram is a metacognition tool that requires students to connect information previously obtained, namely when lectures with new data are obtained through scientific inquiry in the form of practicum [6]. The ability of metacognition is the highest aspect in the cognitive and psychomotor domains [22]. These two aspects can be developed, especially in designing experiments outlined in the form of Vee Diagrams.

4 Conclusion

Vee Diagram, science process skills, and metacognition awareness can predict the ability to design experiments, where each variable contributes to the ability to design experiments. Vee Diagram has the strongest correlation, while metacognition awareness has the lowest correlation.

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