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# Meaningful Biochemistry Learning Using the Orientation-Decision-Do-Discuss-Reflect (OD3R) Method

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The implementation of KKNI curriculum in Indonesia requires meaningful learning–so does the biochemistry learning. In the mean time, biochemistry learning is constrained by the fact that its implementation and assessment have yet to be integrated with classroom learning and laboratory works. The Orientation/Decision/Do/Discuss/Reflect (OD3R) method seeks to integrate the elements and makes biochemistry learning meaningful. The implementation of the OD3R method in 4 universities in Indonesia (N = 216) shows that this method can help students to integrate information obtained from lectures by writing good laboratory reports, improve practical skills, and improving students' scientific attitudes. Each stage in the OD3R method meets cognitive, affective, and psychomotor domains in the biochemistry learning. More details on the OD3R method and its assessment are described in this paper.

Keywords: biochemistry learning, laboratory work report, practical skills, scientific attitudes, meaningful learning

## INTRODUCTION

Since 2012, curriculum of higher education in Indonesia has changed by using the Indonesian National Qualification Framework (KKNI). This change is based on the concept of four education pillars, namely ‘learning to know’, ‘learning to do’, ‘learning to be’, and ‘learning to live together’ that are initiated by the United Nations Educational, Scientific and Cultural Organization (UNESCO). With KKNI, learning

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outcomes are expected to not only consist of knowledge but also attitudes and skills. This also happens to chemistry curriculum in higher education.

Biochemistry is a course that must be taken by undergraduate students of chemistry and chemistry education programs. However, there are problems in the learning process. Students say that biochemistry is a difficult course, in which concepts to study are too many. Moreover, the concepts are irrelevant to students' life and careers (Anwar et al., 2013; Varghese et al., 2012; Afsar & Han, 2014; Anderson & Grayson, 1994; Fulton et al., 2012). In addition, there is no method that is capable of integrating study and laboratory work during learning implementation and assessment (Anwar et al., 2017).

Laboratory work in biochemistry learning does not only serve to prove theories but also to stimulate and to improve skills for lifelong learning (Ottander & Greelson, 2006; Hofstein et al., 2008; Kelly & Finlayson, 2007). Until now, traditional methods remain the only choice for implementation of laboratory work. Students only duplicate methods, record investigation results, and note down the results on reports to which teaching assistants and lecturers never give feedback. To date, there is no method that integrates classroom learning and laboratory works in biochemistry learning implementation and assessment in Indonesia.

Previous research has been developed to improve the implementation of laboratory works. Science Writing Heuristic (SWH) method explicitly addresses students' ability to prepare laboratory work reports (Schroeder & Greenbowe, 2008; Burke et al., 2006; Rudd et al., 2007). Decision/Explanation/Observation/Inference (DEOI) and Process-Orientation Guided Inquary Learning (POGIL) methods focus on the connection between theories and practices (Duzor, 2013; Schroeder et al., 2008). Universal Design for Learning (UDL) approach is to motivate students in the implementation of laboratory works (Miller & Lang, 2016). All of these methods are positive efforts to improve learning by involving laboratory works. By all means, all methods need to be tailored to existing conditions in each university.

The Orientation/Decision/Do/Discuss/Reflect OD3R is a method developed to improve the implementation of biochemistry learning and its laboratory works. This method consists of 5 stages that integrate learning implementation and laboratory works; integrating assessments on cognitive, affective and psychomotor domains as well as providing fun learning activities for students. Structure of the OD3R method is shown in Table 1.

This article aims to examine implementation of the OD3R method in biochemistry learning conducted in 4 universities in Indonesia.

## Literature Review

### *Laboratory Work in Higher Education*

Laboratory work is one of the approaches that can encourage students to develop thinking ability (Hofstein et al., 2008). Aside from that, investigation can also provide stimulus that likely train skills ad develop interests of students on science (Ottander & Grelsson, 2006).

In higher education, laboratory work implementation encounters several problems: (1) many concepts on laboratory work that are yet feasible to do, (2) learning experience gained in the laboratory is not equal to the cost and time spent for laboratory development, (3) students practice overlapping skills (Reid & Shah, 2007). Hawkes (2004) argues that laboratory development only wastes time and funds but does not provide long-term skills training.

The implementation of laboratory works in universities is expected to likely train 3 things, namely practical skills, transferable skills, and intellectual stimulus (Carnduff & Reid, 2003). Bruck & Towns (2009) added that student activities in laboratory should give pupils freedom in generating inquiry procedures and training their communication skills.

Currently, the use of laboratory cookbooks still dominates implementation of laboratory work in higher education. This method emphasizes more on procedures and data obtained (Copriady, 2015). Ault (2002) claims that recipes and procedures are an important part of laboratory work. However, it does not give students opportunity to develop many skills (Reid & Shah, 2007; Monteyne & Cranolice, 2004).

Laboratory works in higher education should give students plenty of opportunities to improve skills and develop lifelong learning ability. To that end, students are given opportunity to design and develop their investigations in an integrated laboratory, as well as training practical skills, improving critical thinking and both verbal and written communication (Limoto & Frederick, 2011; Tsaparlis & Gorezi, 2007; Quitadamo & Kurtz, 2007; Walker & Sampson, 2013; Bruck & Towns, 2010). Thus, the learning is not only beneficial for students but also for lecturers (Jean Burnham, 2013).

*Meaningful Learning*

Ausubel says that learning becomes meaningful when new materials have a systematic relationship with relevant concepts in a long term memory (Ausubel, 1968). Abstract chemistry concepts will produce meaningful learning when they are interconnected to new concepts (Johnstone, 2006).

Bretz (2001) classifies meaningful learning based on 3 criteria: (1) relevant prior knowledge of the student, (2) meaningful material organized by the teacher to connect to this prior knowledge, and (3) the conscious choice of the student to make connections between the prior knowledge and the new meaningful material. Integration between achievements of cognitive, affective and psychomotor domains can lead to meaningful learning (Bretz et al., 2013; DeKorver & Towns, 2015).

In laboratory work, the psychomotor domain relies on the cognitive and affective domains (Galloway & Bretz, 2015). This is in line with current research which explains that human emotions are not limited to only one brain's area (Niedenthal, 2007; Touroutoglou et al., 2015). When a student is engaged in a learning activity and attempting to make sense of a new experience, the brain is inherently recalling previous feelings as well as previous thoughts and actions (Galloway & Bretz, 2015).

## METHOD

### Implementation of OD3R Method

The structure of the OD3R method consists of 5 stages: (1) orientation to generate student motivation, (2) developing/designing the investigation stage, (3) conducting investigations according to resulting design, (4) reporting and discussing investigation results, and (5) reviewing learning that has been conducted (Table 1). The OD3R method is applied to a biochemistry course with subject of qualitative and quantitative analysis on proteins. Prior to the application of OD3R methods, biochemistry learning is conducted using conventional methods that have been used with subject of quantitative and qualitative analysis on carbohydrates. The learning implementation is carried out for 2-4 weeks. In a week, there are 2 meetings. Assessment on each student's activities is done by observers who have previously been trained to use evaluation instruments. Each observer is assigned to keep track of 10 students.

Table 1
The structure of OD3R method

| Phase | What the instructor does that is: | Assessment |
|---|---|---|
| Orientation (O) | a. Lecturer explains competency, lesson activity, and evaluation technique<br>b. Lecturer explains initial discussion briefly<br>c. Group discussion of the given material<br>d. Presentation to discuss the main discussion<br>e. Instruction to discuss preparation to phase 2 of learning | |
| Develop (D) | a. Lecturer gives the students a task to design experimental plan using agreed limitations.<br>b. Presentation of initial design.<br>c. Laboratory work design revision | a. Procedural skill<br>b. Manipulative skill |
| Do (D) | a. Students do laboratory work according to the final design resulted from the discussion.<br>b. Taking notes of the laboratory investigation in the form of a temporary report. | a. Observation skill<br>b. Drawing skill<br>c. Interpreting skill |
| Discuss (D) | a. Students write laboratory work report individually<br>b. Group presentation of investigation result<br>c. Lecturer gives feedback on students' presentations and reports<br>d. Students revise reports | a. Presentation skill<br>b. Laboratory work report assessment (Hoyo Rubric)<br>c. Scientific attitude |
| Reflect (R) | a. Review of the material using article related to the topic and surrounding environment<br>b. Class discussion | |

### Research design

This research is a quasi experiment with one group pretest-posttest design. This design is set to compare outcome variables of samples taken before and after treatment. The treatment is said to be effective if the value of the outcome variable has increased (Mertens, 2015: 138). The research design is shown in Figure 1.

**O1 X O2**
O1 = Outcome Variabel before treatment
X = OD3R Method
O2 = Outcome Variabel after treatment

Figure 1
Research Design in Implementation of OD3R Method

**Participants**

This study is conducted in 4 state universities in Indonesia, namely Yogyakarta State University, State Islamic University Sunan Kalijaga Yogyakarta, Mataram University, and State Islamic University Mataram. Students taking part as participants are those who take biochemistry course for 1 semester (N = 216).

**Research variable**

This research uses 3 variables, which are ability to write a laboratory reports, scientific attitudes, and practical skills. The three variables were tested to the students to see improvements before and after application of the OD3R method.

**Instruments**

A total of 3 instruments were used to measure the three research variables. The student ability to write reports is assessed by using modification of Hoyo rubric (2003). Report components are abstracts, information sources, organization, relevance, contents, and presentation. Each assessment component is scored on a scale of 1 to 4 based on number of criteria that students can fulfill. Scientific attitudes are measured using a questionnaire with 6 types of attitudes: curiosity, open-mindedness, objectivity, honest reporting, responsibility, and mutual respect. Each attitude is developed into 2 indicators which compile some positive and negative statements. Each statement is given 5 choices of answers which are strongly agree, agree, not sure, disagree, and strongly disagree. Practical skills are measured using a rubric with 6 categories of such skills. These categories are procedural skill, manipulative skill, observation skill, drawing skill, interpreting skill, and reporting skill (Kumar, 2010). Each category is developed into several indicators along with achievement criteria. The assessment scores use a scale of 1 to 4.

The modified Hoyo's rubric, the scientific attitude questionnaire and the practical skills rubric are validated through expert judgment of 3 experts. The experts' advice is used to revise the instruments. Instruments declared valid and reliable by the experts are then assessed to 123 respondents. Meanwhile, its validity and reliability values are measured respectively with product moment and alpha cronbach with a help of software SPSS 21. Instruments declared valid and reliable are used in this study (Supporting Information).

**Data analysis**

Assessment on reporting ability, scientific attitudes, and practical skills are calculated using formula of:

$$\frac{\text{Score participant}}{\text{Score max}} \text{ x } 100$$

Average score of reporting ability, scientific attitudes, and practical skills are measured before and after the application of the OD3R method. The OD3R method is said to be effective if scores of the three variables experience an increase after implementation of the OD3R method. The increased is tested statistically using t test to find out significant improvement of the three variables. Supporting data is obtained by asking students' opinions about the OD3R method implementation. Opinions and suggestions from the students are analyzed and described in a form of free response data.

## FINDINGS

### Ability to Write a Laboratory Report with the OD3R Method

The OD3R method implementation in biochemistry learning can improve students' ability in writing laboratory reports. All report components that are assessed experience a significant increase after the method implementation (Figure 2).

Abstract section of the laboratory reports shows the most difficult components compared to other ones. Students assume that abstract has same criteria with conclusion section. Some students make a rather decent abstract after they receive explanation and examples of good abstract writing.

A similar finding is also shown in the information source component. Students use information from more than 5 sources. However, the sources cited come mostly from blogs, instead of books or journals. Consistency in citing quotes needs to be a concern for proper report writing.

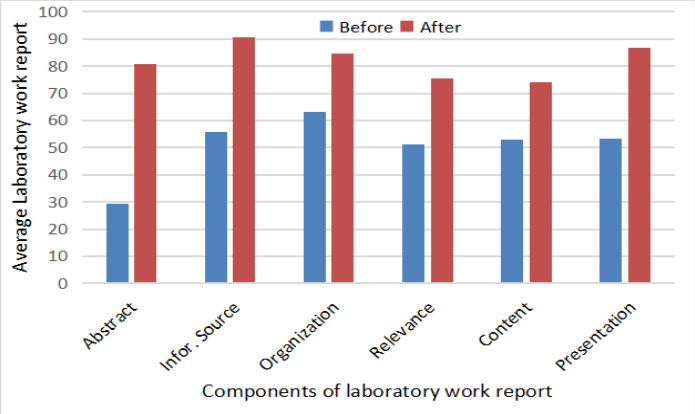


Figure 2
Effect of OD3R method for writing biochemistry laboratory work

Organization and relevance prior to the OD3R method show low scores. The problems are: information displayed in the report is very few; students are unable to integrate

information from lectures with learning sources and activities; and students are unable to connect theories and their application.

Content and presentations are more related to systematic and use of proper language. Reports made by students often use unclear language and, hence, less synthesize information sources obtained. The use of OD3R method is proven to improve proper language systematic and use in the reports.

**Practical Skills with the OD3R Method**

Practical skills experience improvement after the implementation of the OD3R method. Before it, average student practice skill is in average at 49.5. After the implementation, the practice skills increased significantly by 74. Each category of practice skills improved after the OD3R method implementation (Figure 3).

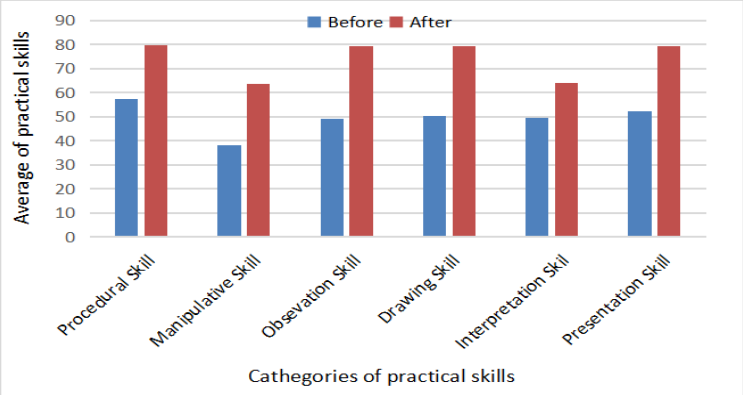


Figure 3
Effect of OD3R method for practical skills

Prior to the OD3R method implementation, procedural skills assessment shows that some students were able to describe investigation purpose, mention tools and materials of the investigations, but they are less capable of executing the investigations properly. Criteria that students have yet to demonstrate are: thoroughly taking into account the materials needed; conducting systematic inquiry procedures. Moreover, many students are still reading investigation instructions while working in the laboratory. After the OD3R method implementation, students are able to conduct systematic, well-organized, and fully calculated investigations.

Manipulative and observational skills evaluation prior to the implementation obtained scores, respectively, of 38 and 49. However, after it, the scores increased by 63 and 79 respectively. The problems encountered in manipulative skills are the ability to design and perform investigation correctly; and accuracy in making observations. Implementation of the OD3R methods helps and familiarizes students in developing and designing investigations, as well as honing their ability to distinguish important and unimportant data.

Drawing and interpretation skills are related to students' ability to prepare laboratory reports. Most students have been able to draw observation tables and graphs but they are less systematic and incomplete. In addition, their ability to interpretation data is very weak while they are also less able to make a good conclusion. As the OD3R method is implemented, it appears that their drawing and interpretation skills are improving.

Before the OD3R implementation, students' weaknesses in communicating the investigation results were seen in the score of reporting skills. Some of the weaknesses are their lack of mastery on materials, unequal team members' contribution during discussions, and students' ability to motivate audience to engage in the discussions. After the implementation, however, the students seem more confident to report the results of their investigations.

**Scientific Attitudes with OD3R Method**

All categories of scientific attitudes have improved after the OD3R implementation (Figure 4). Responsibility is the category that shows the highest score among other categories in scientific attitudes.

Students' experience following biochemistry course with the OD3R method shows a positive response. Students' opinion in a form of comments and suggestions explain:

> "In my opinion, the OD3R method makes the biochemistry course more fun. It becomes easy for me to understand the laboratory instructions and to relate the investigation results to theories I learned in the classroom."

Other student says:

> "Before the OD3R method was implemented, I was often not confident in writing a laboratory report. The OD3R method made me eager to conduct an investigation and made it easier for me to prepare an investigation report."

In addition to the comments, some students give advice on the OD3R implementation. The suggestions are:

"It would be better if the discussions on investigation outcomes were carried out within a longer time so that we could further discuss on our findings. I am very pleased to be given the opportunity to design an investigation as this makes me familiar with the investigation materials."

**DISCUSSION**

The OD3R method is a student-centered learning method that is expected to produce meaningful learning in biochemistry course. Bretz et al. (2013) claims that meaningful learning is a learning that is able to achieve cognitive, affective, and psychomotor aspects in an integrated manner. The role of students as a learning center and lecturers as facilitators is an effort to achieve meaningful learning (Vallori, 2014).

The first stage of the OD3R method is "orientation", which provides an explanation on amino acids, proteins and enzymes, as well as other laboratory aspects related to the respective materials. This stage contains pre-laboratory activities that are able to provide

stimulus to the students to plan their investigations. Previously, the learning only addresses contents and less links laboratory work with the contents. Whereas, content connectivity and laboratory work can help students to initiate an investigation plan (O'Brien & Cameron, 2008; Shallcross et al., 2013; Almroth, 2015). The orientation stage of the OD3R method is able to build students' interest and motivation to remember the contents in a long-term memory (Johnstone et al., 2006; Rollnick et al., 2001; Kelly & Finlayson, 2007).

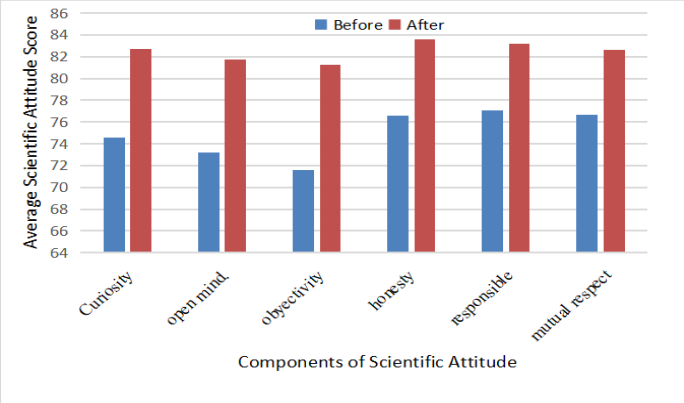


Figure 4
Effect of OD3R method for scientific attitudes

The "decision" stage is the phase of designing and making decisions regarding to inquiry methods that students will undertake. In Indonesia, implementation of laboratory learning still uses cookbooks that feature recipes (Domin, 1999; Ault, 2002). Designing an inquiry is not part of a cookbook laboratory (Copriady, 2015). The decision stage allows students to plan their own investigations so that methods become familiar to them. Moreover, in this stage, basic theory can be strengthened and, hence, allows students to think through their inquiry design. Benefits of drafting an inquiry are that the students can build arguments, improve motivation, and it also produces meaningful learning not only for students but also for teachers (Walker & Sampson, 2013; Miller & Lang; 2016; Jean Burnham, 2013).

The third stage (Do) is the implementation of inquiry designed by the students. This activity trains mostly psychomotor skills. Aside from that, laboratory work can assess affective domains through teamwork. Providing designing opportunities can help students to collect and analyze data appropriately (Hensiek et al., 2016). Laboratory work can help develop students' self-confidence (Gasper & Gardner, 2013).

The inquiry results were reported by the students through laboratory reports and presentation in the fourth stage (Discuss). Writing reports has more advantages than answering questions at exams. In addition to constructing arguments, composing inquiry reports can hone critical thinking skills (Contakes, 2016; Walker & Sampson, 2013; Quitadamo & Kurtz, 2007). The ability to discuss inquiry in reports can relate theories studied in the classroom to laboratory investigation results (Duzor, 2016).

The last stage is "review" which helps students in strengthening their concepts on biochemistry, as well as serving as an assessment on the learning process for lecturers. Through this stage, learning is expected not only to benefit the students but also to give lecturers experience to plan better learning.

The five stages of the OD3R method can improve reporting skills, scientific attitudes, and practice skills. Students' ability to write reports belongs to the cognitive domain; practice skills are at psychomotor and affective domains; scientific attitudes are in the affective domain. Scores of all three domains experience an increase through the OD3R method, which then proves it capable of producing meaningful learning in biochemistry. According to Galloway & Bretz (2015), the psychomotor domain depends on what students think (cognitive) and how they feel about the lab experience (affective).

The "orientation" is the stage that can generate students' motivation to better understand biochemistry (affective). The "decision" stage trains students in designing group investigations so that it can develop cognitive and affective domains. The "do" stage requires many skills to conduct investigations, such as observation, manipulative, drawing, data interpretation, and teaming skills – these skills include cognitive, psychomotor, and affective domains. The "discuss" stage is where the students report inquiry results in the form of written reports and presentations, which develop their cognitive, psychomotor, and affective domains. The final stage of "review" has more to do with their responses to biochemistry learning demonstrated through scientific attitudes. Each stage of the OD3R method, along with the learning domains, is shown in Figure 5.

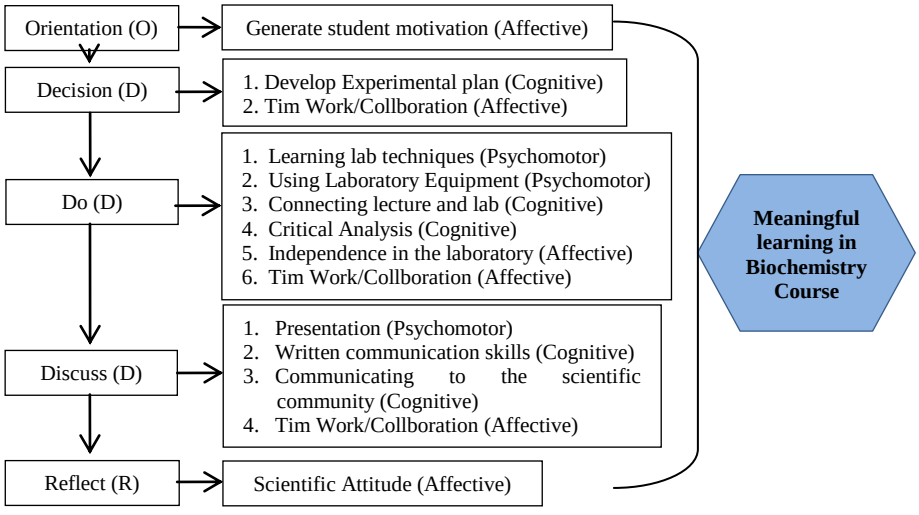


Figure 5

Relationships among OD3R Method for Meaningful Learning In Biochemistry Course

## CONCLUSION

The OD3R method can improve the ability to write report and practical skills, and develop students' scientific attitudes. The stage of designing an investigation and conducting an inquiry is the phase that is capable of developing the students' cognitive, psychomotor, and affective domains. Thus, the OD3R method can be used to achieve meaningful learning on biochemistry.

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