**Article**

The Use of Orientation/Decision/Do/Discuss/Reflect (Od3r) Method to Increase Critical Thinking Skill and Practical Skill in Biochemistry Learning

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**Abstract**

We have developed an OD3R method that can be applied on Biochemistry learning. This OD3R consists of 5 phases: orientation, decision, do, discuss, and reflect to connect lessons in the class with practice in the laboratory. Implementation of OD3R method was done in 2 universities in Yogyakarta to increase critical thinking skill and practical skill of the students. The critical thinking skills were assessed using modified Hoyo rubric according to student’s ability in writing laboratory work report. Practical skill was assessed using a rubric with 6 practical skill categories: procedural skill, manipulative skill, observation skill, drawing skill, interpretation skill, and presentation skill. Implementation result shows that OD3R method can increase critical thinking skill and practical skill of the students. OD3R method is a learning method that is centered on the students and can be recommended to train thinking skill and practical skill of students in University, © 2017 by The International Union of Biochemistry and Molecular Biology, 00:000–000, 2017.

**Keywords:** Biochemistry learning; laboratory work; critical thinking skill; practical skill

**Introduction**

Biochemistry is a dynamic branch of science with five main foundations: cellular, chemistry, physics, genetics, and evolution [1, 2]. The application of biochemistry includes agriculture, medical, pharmacology, and toxicology. Topics discussed in biochemistry are interesting, but need a high order thinking skills [3].

In the curriculum of Indonesian universities, biochemistry is a basic subject that needs to be taken by students of chemistry education. The main discussion for 1 year of learning includes structure and metabolism of protein, nucleic acid, carbohydrate, and lipid [4].

The broad and complicated concept becomes a problem in biochemistry learning. Broman et al. [5] took notes on opinions from high school students who considered biochemistry as a difficult subject. In university level, biochemistry is considered incomprehensible and irrelevant with neither their career nor their life as students [6–9]. Difficulties are not only faced by students, but also by the lecturer of the subject [10].

As a science subject, biochemistry involves laboratory work in the learning process. Laboratory work is expected to bridge theory with practice [11]. However, laboratory work can increase students’ understanding, argumentation, and confidence [12, 13].

In the university, laboratory work does not only train students’ psychomotor skills, but also train thinking skills and scientific attitudes [14, 15]. In biochemistry, we saw several problems in the practice of laboratory work. For
instance, the lack of integration between theories taught in class and the use of cookbook laboratory that took a dominant part in practice [16].

Several research reports the methods that could be used to integrate theory and practice in the laboratory. Duzor [17] used the method of decision/explanation/observation/inference (DEOI) to bridge theory and practice in laboratory. The method of Science Writing Heuristic (SWH), model/observe/reflect/explain (MORE), Process-Oriented Guided Inquiry Learning (POGIL), and Argument-Driven Inquiry (ADI) are among the methods used to relate theory with practice in the laboratory [18–22]. However, many of these methods have not been able to integrate practical skills assessment in their implementation.

Orientation/Develop/Do/Discuss/Reflect (OD3R) Method was developed to integrate theory and laboratory work. In Indonesia, mostly the laboratory work only repeats the methods mentioned in the laboratory guidelines. The theory taught in the class could not be integrated with the practice of laboratory work yet [16]. According to Reid and Shah [15], learning in laboratory can be effective if the pre-laboratory activity, laboratory work, and post task can be integrated well. Theory integration and laboratory work are expected to increase the critical thinking skill and practical skill in biochemistry class.

The steps of OD3R method consist of 5 phases as follows: orientation, develop, do, discuss, and reflect. OD3R Method structure is shown in Table I. Students are given opportunities to designed their experiment, do experiment, and to connect their result and theory that they have done in class. Thus, laboratory work results can be connected with lecture.

### Methods

#### Assessment Design

Assessment using OD3R method is divided into 2 steps, namely assessment of critical thinking skill and practical skill. Critical thinking skill is assessed through laboratory work report using modified Hoyo rubric [23]. This rubric evaluates writing competency based on abstract, source of information, organization, Relevance, content, and presentation characteristics. Characteristics in students’ writing can be related with cognitive competency in Bloom taxonomy. Each trait is given scores with scale ranging from 1 to 4 with 1 shows lowest score and 4 as the highest.

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

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**TABLE I**  
*The steps of OD3R method*
Assessment of practical skill shows category developed by Kumar [24]. There are 6 categories used: procedural skill, manipulative skill, observation skill, drawing skill, interpreting skill, and reporting skill. Each skill is developed into several indicators and characteristic for the assessment. Each trait is given scores ranging from the scale of 1 to 4 with 1 shows lowest score and 4 as the highest. Critical thinking skill and practical skill rubrics can be found in the Supplementary Information.

Validity and Reliability
The validity and reliability of the assessment rubric for laboratory work report and practical skill was measured by expert agreement. Three experts in chemistry and biochemistry education were involved in the instrument assessment. Expert agreement referred to the calculation of Aiken index with instrument criteria is valid if Aiken index is above 0.4 [25, 26]. The calculation of average Aiken index shows that validity score of modified Hoyo rubric and practical skill rubric are 0.722 and 0.806 respectively.

The reliability of modified Hoyo rubric and practical skill rubric was calculated using Interclass Correlation Coefficients (ICC) because the raters were more than two people. The instrument is declared reliable if ICC is above 0.4 [27]. The ICC score counted using SPSS 21 showed reliability score of modified Hoyo rubric and practical skill rubric as 0.667 and 0.635. From the ICC score, the instrument is declared as reliable.

Implementation of OD3R Method
OD3R Method was tried out on students of chemistry education who took the Biochemistry class. The universities sample were Yogyakarta State University and Islam State University of Sunan Kalijaga Yogyakarta with total sample of 155 student. Quasi experiment was used for model trial, with one group pretest-posttest design. This design compares outcome variable from pre and post treatment. The treatment is declared effective if the outcome variable increases.

There were 2 variables of research that was put on test; critical thinking skill and practical skill. Research data was analyzed by comparing the average of the two variables from pre and post treatment.

Results
The research result shows that OD3F method can increase students’ critical thinking skill. Laboratory work report average score increased significantly after the application of method OD3R ($p < 0.05$). All components of biochemistry laboratory work report such as abstract, source of information, organization, relevance, contents, and presentation increased after OD3R method application (Fig. 1).

Abstract component to the laboratory work report shows the increase of scores before and after treatment. Average score before treatment was 27.5 which increased after the application of OD3R method to 66.25. In the abstract writing, all criteria to write abstract cannot be found in student report. Hoyo [23] reported that abstract writing is one of the problems faced by chemistry education students. Along with this research, students tended to have a perception that an abstract is the same with the conclusion. Gupta [28] reported that from 10 students who were the research subject, 7 students did not meet the criteria in Hoyo rubric. The use of Science Writing Heuristic (SWH) approach can increase the score of abstract scoring.

The average score of the source of information before the treatment was 60.625 and it increased after the application of OD3R method to 83.44. Before the treatment, students tended to use at least 5 information sources, mostly from blog posts. The first criterion related to the information source has been met by students. However, the use of primary source such as journals and books was not yet put into effect. Besides, the consistency of bibliography writing and detail still needed to improve. Often, the students did not mention the source consulted in the bibliography. Information source component in Hoyo rubric regards accuracy, consistency, relevancy, and evidence from the critical thinking indicators.

Organization component in Hoyo rubric is related to the students’ skill to analyze investigation result. Implementing OD3R method resulted in the increase of average score of 63.75 to 79.06. Criteria shown before the treatment was that the information shown were illogical and inaccurate. Some students already met the three criteria mentioned in the Hoyo rubric after the application of OD3R method.

Relevance in the Hoyo rubric can be used to know the critical thinking skill with the indicators of clarity, accuracy, relevancy, evidence, and depth. OD3R method implementation shows the increase of average score of relevance components from 54.06 to 79.69. Relevance can be assessed from students’ competence in discussing their investigation result. Before the treatment, the students spent more time rewriting their investigation and working procedure. Investigation result and the relation with theory as well as information they obtain during the class session...
cannot be conveyed clearly. In accordance with Hoyo [23], the students of chemistry education could not yet integrate the information obtained in class sessions, theory, and theory application. Gupta [28] reported that 8 from 10 subjects did not meet any criteria in the relevancy component.

The result of OD3R method application on content components shows a significant increase on scores in which before the treatment it scored 56.56 and increased to 76.56 after treatment. The students’ competency in meeting the three criteria on the content components shows that critical thinking indicator is the one mostly met compared to others. Critical thinking indicators met content components includes clarity, accuracy, consistency, relevancy, argumentation, depth, breadth, and equality. Gupta [28] reported that content components in Hoyo rubric is the component with the lowest assessment in students’ laboratory work report. Before the use of Science Writing Heuristic (SWH), all of the subjects did not meet the assessment criteria. The use of SWH approach in the third month shows the increase of students’ who met the criteria as much as 50%.

Presentation is the last component assessed in Hoyo rubric. The application of OD3R method gave higher score average (78.75) compared to before the treatment (56.25). The most unmet criterion was the limited systematic writing comprehension.

Along with the critical thinking comprehension, OD3R method application could increase the students’ practical skill holistically. Before the application of the method, the average of practical skill obtained by the students are 51.9. The application of OD3R method showed that the average of practical skill increased to 71.22. The rise on the practical skill score in the implementation of OD3R method is shown in Fig. 2.

There were six practical skills measured. The first category is procedural skill, including the students’ comprehension in elaborating practice objectives, determining devices and ingredients from the practice, and conducting the practice procedure. Average score of the procedural skill obtained before the treatment was 62.25. The criteria for procedural treatment seen from the students include the facts that they were able to elaborate the general objective of the practice; able to elaborate the needed devices and ingredients, the able to use research instruments; unable to calculate the needed ingredients which required them to do repetition of the process; lacking the ability to utilize temporary report that they had made, and the use of practice guidelines in investigation. The application of OD3R method could improve procedural skill score. Students were able to elaborate specific practice objectives and make use the practice design made during the laboratory activity.

The second practical skill category measured in this research is the manipulative skill. In the first indicator, several students already could write investigation steps correctly. However, drilling in the systematic writing for laboratory work design to familiarize the students with the process. From the three indicators, observation shows that the comprehension in writing analytic procedure was not yet seen and almost every students should be became confused in determining investigation data analysis. Manipulative skill score shows the lowest average score out of all categories in practical skill. Before the treatment, manipulative skill scored 35.625, and after the application of OD3R method, it increased to 52.79.

Observation skill score increased significantly to after compared to before the treatment. The score before the treatment shows 51.81 with the criteria that had not been met related to accuracy and observation systematic done. In the application of OD3R, observation skill increased significantly to 78.56.

Before the implementation of OD3R method, drawing skill (computer graphics) average score was 53.53. After the application of OD3R model, the average score increased significantly to 71. Students were able to make a good observation table as well as giving clear names to columns and row. However the presentation of tables and graphics were not yet systematic. After the application of OD3R method, students could improve the systematics of observation table and graphic presentation.

Interpretation skill score before the treatment (51.42) increased significantly after the application of OD3R method (66.75). Students could record the data resulted from the observation but could not yet relate it with the given theory. The students tended to draw conclusions by repeating statements written in the theoretical review. After the application of OD3R method, improvements were shown in the students’ interpretation skill.

Reporting skill was scored based on the presentation comprehension that was shown by the students in the class. Before the treatment, students’ presentation skill was shown as good. Average score of the reporting skill before the treatment was 56.14, increased significantly after the implementation of the OD3R method to 76.71. Several
things to improve included the lack of material mastery, shown by many students who just read their notes in the presentation; disproportional member contribution in the team; and the lack of ability to motivate audience to discuss. The use of OD3R method could increase students’ comprehension in live presentation and proportional team member contributions.

Discussion

Biochemistry lessons with laboratory work is a part of chemistry education curriculum in Indonesia. Until today, the use of laboratory work undergoes several problems. The problems, among others, are the dominant use of cookbook laboratory, laboratory work steps that are not related with classroom lessons, and nonessential laboratory work feedback. Those problems result in negative perspective from the students [16]. Besides those problems, there are many skills that did not get the time portion to train because the problems need to be solved first.

The OD3R method is developed to reduce the dominant use of recipe or procedure stated significantly in the laboratory cookbook. OD3R method phase could relate the lessons in the class and laboratory work as well as significant feedback through the relation.

The use of OD3R method to two different universities indicates the improvement of the students’ critical thinking skill and practical skill. The five phases developed from the OD3R method could increase the students’ thinking skill, shown by the ability to make a good laboratory work report and the increase in the students’ practical skill in terms of the skill in making investigation.

The first phase of OD3R method is orientation, which is where the students obtain general understanding of the lesson content. In our research, we used materials such as amino acid, protein, and enzyme that could be explained using discussion method to the students. This phase could be considered as the prelab phase in which the students were motivated and helped to relate the content with the investigation that they are about to do. The last step of the phase is when the lecturer assigns tasks to the students to develop their investigation plan with qualitative and quantitative analysis of protein in a sample, as a topic of subject. The orientation step is important to get stimulus to the students before doing investigation. In accordance to several experts’ opinion that through orientation or prelab, investigation becomes more meaningful, drilling many skills especially in initiating investigation plan so that the students can memorize in long-term [29–31].

The second phase as the investigation design phase is the phase that differentiate the study in the classroom of Biochemistry. Laboratory cookbook emphasizes more on the recipe and procedure that tend to repeat instructions given by the lecturer [32, 33]. The planning phase and investigation plan writing phase are removed from the laboratory cookbook [34]. The steps on the second phase that have to be done by the student groups are determining the objective of the study, searching for the literature method that could be used to achieve that objective, taking decision on which method to use, and assembling procedure done to achieve that objective. The skill to design an investigation is one indication why OD3R model could increase the critical thinking skill and students’ practical skill. In accordance with inquiry and problem-based laboratory that give chance to the students to design investigation so that it can increase the practical and critical thinking skill [35–38]. Through the chance to design the investigation with integrated classroom sessions, practical skill, transferable skill, and intellectual stimulus as the purpose for university laboratory could be trained [39–41].

Investigation design resulted in the second phase could be used for the laboratory work on phase 3. Phase “do” helps the students to train some skills such as utilizing the instruments in the laboratory, doing procedures planned, taking notes of the investigation data accurately, analyze the research data, present data systematically, and interpretation of investigation data. The result of the investigation is evaluated holistically through the students’ comprehension in assembling the investigation result report. Through laboratory work, students could relate theory studied with the investigation result that they found. According to Reid and Shah [15] an effective laboratory work could help train many skills. Furthermore, confidence and critical thinking skill could increase [13, 42].

Investigation result was reported through presentation, writing, and class presentation in the fourth phase. The lecturer gave feedback from the writing and discussion of the students. Feedback is an important step to motivate students so that they could interpret and produce good quality writing. Research result showed that critical thinking skill of the students increased after the application of OD3R method based on the modified Hoyo rubric. This development was fueled by the feedback given by the lecturer and the discussion which broadened the students’ mind to produce a better report. In accordance with research by Contakes [43] and Walker and Sampson [22] which reported that the investigation report could help building argument and students’ critical thinking. Through report writing, theory obtained in the classroom could be related with the investigation in laboratory [17].

The last phase is the “reflect”, whose objective is to strengthen and evaluate the content learned. Review could be done with discussion and analysis of the relation between the learned content with the content to learn next. This phase could be beneficial for the lecturer to improve the learning session of the next content. All of the phases on OD3R method comprise a student centered learning and can be used to train thinking skill as well as practice skill of university students.
Conclusion
We concluded that OD3R method can increase students’ critical thinking based on Hoyo rubric. This is seen from the students’ comprehension in assembling a better investigation report after the application of OD3R method in terms of abstract writing, information source presentation, the use of clear format, data interpretation skill, and investigation result explanation skill, and the use of intelligible language. Besides critical thinking skill, OD3R method could increase practice skill such as the skill in designing investigation, the skill in conducting investigation, collecting investigation data, presenting investigation data, and reporting investigation result through presentation.

References
