The Development of Contextual Collaborative Learning Model for Chemical Bonding Course

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Abstract—Research about the contextual collaborative learning model for chemical bonding course has been carried out. Through this concept, the learning process is conducted by combining the conventional lecture by the lecturer and the foreign lecturer and the combination with computational chemistry. The result of cognitive evaluation test at the beginning of the course showed that the distribution of understanding of each class is not different significantly. This gives an overview that the classes consist of homogenous students, thus, the comparison could be performed objectively. The result of the evaluation test in order to understand the students’ response to the perception and interest showed a different effect at two classes. This might be due to the difference of the teaching performance of the lecturers in the first and the second classes. The attendance of the foreign lecturer and the use of computational media have proven to give a positive impact for the learning process.

Keywords: collaborative, contextual, computation, chemical bonding

I. Introduction

Chemical bonding course is a mandatory course which is full of theory as well as philosophic concept and is closely related to physics. Thus, the learning process is often trapped in mathematical approach and not giving a clear chemistry description to the students (an example is given in Figure 1).

One of the techniques that can be developed to solve the problems above is conceptual teaching method. Basically, the conceptual method emphasizes in the enrichment of the student’s basic knowledge by involving some actors in the curriculum development, for example the visualization approach of chemical bonding\(^1\).

![Figure 1](example.png)

**Figure 1.** An example of mathematic approach in teaching materials of chemical bonding course

The visualization has a broad scope. It is not only for the theory proofing but also for the enrichment of the conceptual understanding as well as the interest of the students. According to these, computational chemistry can be adopted as one of the visualization media, thus, the improvement of the lecturer’s expertise about computational chemistry is urgently needed. By combining the visualization using computational
chemistry as a part of conceptual approach and the improvement of the lecturer’s expertise, this research was carried out to develop the model of conceptual collaborative learning by inviting an expert lecturer from abroad.

Research Objectives

This research aims at: Understanding the effects of the attendance of an expert foreign lecturer by developing a design of contextual collaborative class and increasing the cognitive, affection and psychomotor achievements of the students.

II. Methods

Research Methods

Research was carried out at Chemistry Department, Faculty of Mathematics and Sciences of Universitas Islam Indonesia, Yogyakarta on the 3rd semester students for 6 months, starting from September 2015 to February 2016. The subject of the research is students; two classes of students to participate in the collaborative class which involves the expert foreign lecturer (for 1 week) and two classes of students to participate in the conventional teaching method as a comparison.

The curriculum team of Chemistry Department of UII has arranged a concept map for chemical bonding course as illustrated in Figure 2.

![Figure 2. The concept map of chemical bonding course.](image)

Based on the concept map in Figure 2, the development method for the learning system of chemical bonding course will be carried out in some steps:

The class evaluation which is needed for the development of the learning design for chemical bonding includes:

1. The class pre-evaluation, conducted via online system using the Computer Based Competence Evaluation (CBCE) program. It is to observe the initial knowledge of the students related to the course materials in chemical bonding course.

2. The observation of how far the utilization of computer and multimedia technology in the class are.

3. How the design of the assignments given to the students is conducted to accelerate the achievement learning target [2].

The evaluation carried out for the students is needed to group the students according to their cognitive skill.

ii. The design of the class action

The design of the class action is applied in each two classes of experiment and two classes of conventional teaching. Schematically, the design of the class action is given in Figure 3. According to the design of the class action, the information about whether the learning process given to the students will have a positive
impact or not could be obtained. If the learning process gives a positive impact, the further follow-up and the development will be conducted and finally followed by the final evaluation.

![Diagram of class action design]

**Figure 3.** The design of the class action

The output of the final evaluation will be in the forms of course plan, course outline, etc.

II. Results and Discussion

The learning process using this collaborative concept aims at making it easier for the students to understand the given course. The targets and the indicators of the program are given in Table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Indicator</th>
<th>Baseline</th>
<th>Learning achievement target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>course plan</td>
<td>available-without the collaborative conceptual approach</td>
<td>available course plan and course outline with computational module approach</td>
</tr>
<tr>
<td>2</td>
<td>the availability of teaching material</td>
<td>available module with course plan approach</td>
<td>available draft of learning book with collaborative conceptual approach</td>
</tr>
<tr>
<td>3</td>
<td>the availability of learning tool</td>
<td>not yet available</td>
<td>available mini computer laboratory and software with learning plan approach</td>
</tr>
<tr>
<td>4</td>
<td>average score of students</td>
<td>-</td>
<td>increasing of average score academic students</td>
</tr>
<tr>
<td>5</td>
<td>score of lecture performance</td>
<td>3.33</td>
<td>&gt;3.50</td>
</tr>
</tbody>
</table>

**Implementation**

Most of the students think that the physical chemistry course (in this case is chemical bonding course) is more difficult than the other courses [3]. Many approaches in the development of physical chemistry learning method have been conducted to increase the passion and interest of the students. The activities in each session are given in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>The activities</th>
<th>Significant findings</th>
<th>No</th>
<th>The activities</th>
<th>Significant findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- The presentation about the program</td>
<td>A positive respond of the students to the visualization of chemical bonding course material. This respond was shown by a 'curious character'</td>
<td>4</td>
<td>Lecture using computational method/visualization</td>
<td>Students have a positive respond regarding the activity. It was shown by the activity of each student in answering the given questions in front</td>
</tr>
<tr>
<td>2</td>
<td>Classes are divided into two groups. Group I (Class A and B) was the group in which the conventional teaching method was implemented—without a foreign lecturer and the introduction to computational chemistry. Group II (Class C and D) was the group in which the program was implemented—the presence of a foreign lecture and introduction to computational chemistry.</td>
<td>The first term (before midterm) of the course is given conventionally. The lecturer gives a lecture and delivers the course material using whiteboard as a media and gives an example of problem afterwards. The respond of the students which have high motivation and cognitive ability to solve the problems given in front of the class. The second term (after midterm) of the course, the students are divided into 5 groups, and each group was represented by a student to present the result of the discussion. The positive respond from the students was shown by the activity of the students to participate in solving the problems. Students are interested to the term of energy in quantum chemistry. In this term, at least 10% of the students were active in giving questions and respond.</td>
<td>Conventional lecture is used to evaluate the limitation of the lecture with a foreign lecturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Classic lecture by the foreign lecturer</td>
<td>The respond of the students which have high motivation and cognitive ability to solve the problems given in front of the class.</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For the next step, learning session is conducted regularly by the course lecturer using scientific group as a control. In a whole, the classes consist of four groups: class A and B in which the program is not applied and class C and D in which the program is applied.

According to some questions given in the class quiz, the students can be grouped into three groups:
- The group in which tutorial is recommended
- The group in which tutorial is needed
- The group which is allowed to not participate in the tutorial

The result of cognitive evaluation in each class is illustrated in Figure 4.

![Figure 4. The result of cognitive evaluation](image)

The evaluation for class C and D includes the cognitive and perception aspects. The evaluation grade for the cognitive and perception aspects is shown in Table 3.

In Table 3, the students give score as follows: 1: highly agree; 2: agree; 3: doubtful; 4: disagree; 5: highly disagree.

<table>
<thead>
<tr>
<th>No</th>
<th>Component</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interest</td>
<td>The course material of chemical bonding is interesting for me</td>
</tr>
<tr>
<td>2</td>
<td>Perception</td>
<td>A foreign expert lecturer will help the student to learn</td>
</tr>
<tr>
<td>3</td>
<td>Cognitive perception</td>
<td>Computational chemistry will help the student to learn.</td>
</tr>
<tr>
<td>4</td>
<td>Cognitive perception</td>
<td>Chemical bonding helps the student to learn about other courses</td>
</tr>
<tr>
<td>5</td>
<td>Cognitive</td>
<td>Chemical bonding is related to computational chemistry</td>
</tr>
</tbody>
</table>

According to the result of evaluation in Figure 5, the program does not have a significant effect in class D. The perception score is relatively good with the value of 80%. This shows that the students have a positive perception for the program.

A unique finding is shown in the aspect of interest for question number 1: the course material of chemical bonding is interesting for me. In class C, there is a decrease of the response after the program, while in class D, there is an increasing response after the program. This indicates that the teaching-learning process that involves a foreign expert lecture gives a different effect in each class.
Figure 5. The evaluation result of the perception and interest of the students before and after the program, in (a) Class C (b) Class D.
Table 4. Activity and target of the program that involves a foreign expert lecturer

<table>
<thead>
<tr>
<th>No</th>
<th>Activity</th>
<th>Program Targets</th>
<th>Results</th>
</tr>
</thead>
</table>
| 1  | Lecture in class C and D (3 sessions) | ✓ Introduction and standardization of chemical bonding course materials according to *Royal Society of Chemistry* (RSC) curriculum  
 ✓ The observation of interest, perception and respond of the students  
 ✓ The observation of student’s activity | ✓ Students are active in giving questions  
 ✓ Students look enthusiastic |
| 2  | Lecture/Workshop in a large class (Plenary) (one session with class C and D) | ✓ The observation of interest, perception and respond of the students comparatively between classes  
 ✓ The observation of student’s activity | ✓ Students are active in giving questions |
| 3  | Lecture/Workshop in a large class (Plenary) (one session with class A and B) | ✓ The observation of interest, perception and respond of the students comparatively between classes in which the program is applied and classes in which the program is not applied  
 ✓ The observation of student’s activity | ✓ The students are active and gain a new insight in chemical bonding course given by a foreign expert lecture |
| 4  | Practical course using computer (class C and D) | ✓ Introduction and standardization of chemical bonding course materials according to RSC curriculum  
 ✓ Introduction, relation between the course and other courses  
 ✓ Visualization | ✓ Students have a clear idea about the relation between chemical bonding course and computational chemistry  
 ✓ The availability of module which can be inserted into the suitable practical course |

Table 5. The map learning outcomes and the assessed aspects

<table>
<thead>
<tr>
<th>No</th>
<th>Learning Outcomes</th>
<th>Materials/Example of question</th>
<th>Assessed aspects</th>
</tr>
</thead>
</table>
| 1  | CP24: Apply logic, critical, systematic and innovative thinking in the context of the development or the implementation of sciences and/or technology according to student’s field of expertise; | Bonding formation  
 Example:  
 1. Mention three theories that become the bases for the development of Quantum Mechanics theory, please explain.  
 2. Explain the meaning and properties of $\psi$ which is differentiated from the Schrödinger wave equation and the position of atom in Quantum Mechanics theory. | ✓ Understanding  
 ✓ Knowledge  
 Students understand the development of quantum mechanics theory |
| 2  | CP25: Draw an appropriate decision to solve a problem related to student’s field of expertise, based on the analysis result of the information and data | Orbital  
 Example:  
 1. Explain the steps for Schrödinger wave equation until the geometry of orbital is obtained (for example: s orbital is ball shape, etc.)  
 2. Why is $\text{N}_2$ formed while $\text{He}_2$ is not? | ✓ Analysis  
 ✓ Synthesis  
 ✓ Evaluation |
| 3  | CP27: Manage the self-learning process | Quiz and assignments | ✓ Knowledge: recall, remember information |

III. Conclusion

The learning process of chemical bonding course can be conducted using the conceptual collaborative approach through the evaluation of the perception and interest of the students as well as the combination
with other courses, especially computational chemistry. The presence of a foreign expert lecturer gave a positive impact in the teaching and learning process.

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References

