The effect of problem-based learning model toward students’ conceptual understanding and verbal communication skills in reaction rate learning

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Abstract. This quasi-experimental study aims to determine the effect of applying Problem Based Learning (PBL) model toward students’ conceptual understanding and verbal skills in learning reaction rate materials. It is designed using posttest only control group design subjecting the students of SMAN 1 Poco Ranaka. The PBL model was applied to the experimental class while 5E Learning Cycle model was treated for the control class. The data was collected using the observation sheet of verbal communication skills, posttest of students’ conceptual understanding, and the questionnaire of students’ response to the application PBL model. The data of observation and posttest, analyzed using MANOVA, revealed the significant effect of applying PBL model toward students’ conceptual understanding and verbal communication skills with $P = 0.000 < 0.05$ of significance level. The percentage of contribution given by PBL model to the improvement of students’ conceptual understanding and verbal communication skills was also analyzed. The percentage of contribution of PBL model to the improvement of students’ conceptual understanding and verbal communication skills was, respectively, 22.26% and 33.17%, both with $P = 0.000 < 0.05$ of significance level. This shows the positive effect of applying PBL model on the two variables, though still in low and medium category of contribution. The result of questionnaire analysis using quantitative descriptive, students give positive response to the application of PBL model. Thus, it is concluded that the application of PBL model effects positively to the student’s conceptual understanding as well as verbal communication skills.

1. Introduction
Learning is essentially to move forward to the state of more knowing, understanding and/or applying something. To achieve such goal, learning should be considered as a process to ship students from the state of their current knowledge to the proximate ideal target knowledge. As in other countries, Indonesian government have made change of the curriculum, the major tool of that students’ knowledge shifting process, by taking into consideration the distance between these two knowledge edges (the current knowledge and the target knowledge). It is done for the final desired purpose which is to improve the quality of national education. In line with this, the Ministerial Ordinance of National Education Ministry No. 41 year 2007 [1] have ruled the process standard of education in which the role of teachers is...
important to plan and execute well-designed learning, in line with the set curriculum, to achieve national education purpose [2].

Realizing that learning should be designed to the enhancement of students’ knowledge end, learning practice nowadays has turned out attention to the importance of having students’ active engagement and involvement in constructing their knowledge. This perspective, in more or less portion, is influenced by the constructivism theory of cognitive psychology proposed by Piaget and Vigotsky where students are treated to be the main actor of constructing their own knowledge while teachers act to scaffold or facilitate the construction [3]. This view of learning may give positive contribution to students’ learning achievement in as an abstract subject as chemistry. It is due to the fact that the effort of shifting students’ knowledge on this typical subject might be much more challenging, resulting to high demand of teachers’ ability to provide learning in an innovative and meaningful way.

One fruitful learning model being able to trigger students’ knowledge construction and to be usefully applied in chemistry class is Problem Based Learning (PBL) model. PBL model, the strategies of which may include posing students to the contextual problem, searching for the problem-related concept, and articulating the problem solving, is believed to abundantly promote both students’ conceptual understanding and verbal communication skills. In its very essence, PBL model is naturally reduced, constricting the learning of concepts for the purpose of problem solving. It will enable students to focus more on learning the specific concepts, deepening their understanding of those concepts, while simultaneously thinking about the way they could apply such concepts to solve the given problem. PBL model facilitates students to learn, find out, and apply the knowledge they learn from any sources such as from online, library, and experts [4] which consequently results to students’ achievement of conceptual understanding. Aside from being able to promote students’ understanding to problem-related concepts, applying PBL model is also beneficial for the development of students’ verbal communication skills. For its problem solving purposes, PBL model offers encouragement of students’ development of verbal communication skills on at least its three learning stages. First, on the stage of problem investigation, students are encouraged to articulate the known concepts in searching for understating toward the assumptions and hypotheses of the investigated problem [5]. Second, on the stage of problem solving development and result presentation, students are fostered to present and articulate in a proper manner the result of their working on problem by which they are potentially facilitated to develop their independent learning ability [6]. Third, on the stage of analysis and evaluation, the students are encouraged to share their experience of problem investigation process and cooperatively construct the evaluation and conclusion regarding the learning content with peers and the teacher. Thus, by its ability to have students being active in each learning stage, PBL aids students to develop their skills in communicating, arguing, and investigating the problem and the problem-solving process [7].

Regardless those abundant potentialities of PBL model, the theoretical and the empirical problems have been revealed in terms of students’ conceptual understanding and verbal communication skills, particularly in chemistry learning. In his study, Setiyono [8] reports that in learning the abstract materials in chemistry, students tend to memorize and perform the direct application of the learnt concept and take less effort to understand the concept which could be stored in students’ long-term memory. Memorizing the concepts, however, only rests in students’ short-term memory, gives no contribution to solve analytical problems, and will not be useful to fulfill students’ future needs. As the result of having no well-structured conceptual understanding, the students will in turn find difficulties in communicating the learnt concepts. The empirical problem related to these issues correspondingly echoes and emphasizes the same result. From the preliminary interview to some chemistry teachers in several schools at Manggarai Timur Regency of Nusa Tenggara Timur Province, it is found that students have problems both in conceptual understanding and verbal communication skills in a reciprocal way. In one hand, the shallowness of students’ conceptual understanding, due to their memorizing learning habits, effects to their inability to
establish and articulate their understanding using appropriate verbal communication when they are assigned to present, argue or clarify their learning results. On the other hand, since the learning models applied by the teachers in their classrooms do not give enough opportunity for students to practice their verbal communication skills, the students tend to be defensive, relying their learning highly on their teachers without being motivated to search for other learning resources to deepen their understanding.

In respect to these problems while glancing on the theoretical preeminence of PBL model, this study is conducted to investigate the effect of applying PBL model toward students’ conceptual understanding and verbal communication skills in learning reaction rate materials. The learning topic was chosen based on the assumption that reaction rate material is one of learning topics in chemistry that would trigger students to relate their learning content to the contextual problems they can identify in daily life experience. In line with its daily identifiable and observable problems, the students will be indirectly posed to the abstract concepts of reaction rate learning material but be prepared for the concepts they engage every day. To do so, this study is conducted with the objectives formulated as follows.

1) Investigating the effect of applying Problem Based Learning model to students’ conceptual understanding and verbal communication skills.
2) Analyzing the contribution of Problem Based Learning model to students’ conceptual understanding.
3) Analyzing the contribution of Problem Based Learning model to students’ verbal communication skills.

2. Methods
This study was quasi experimental using posttest only control group design [9]. The research subject was the first semester of XI class in the academic year 2018/2019. The population was the senior high schools in Manggarai Timur regency which were equal to or parallel with the first public senior high school (SMAN I) of Poco Ranaka. Using random sampling technique, the sample of this research was the 63 students of SMAN I Poco Ranaka, divided into two groups: experimental group (31 students) and control group (32 students). The experimental group was taught by applying PBL model and the control group was taught using 5E Learning Cycle model. The learning topic chosen for both groups was reaction rate learning materials.

Data were collected by conducting the observation, assigning the posttest, and distributing the questionnaire. The observation was done to observe students’ verbal communication skills in the learning process of those two classes. The posttest was given to investigate students’ conceptual understanding on reaction rate materials after the application of the aforementioned models in each researched class. The questionnaire, in addition, was distributed only for the experimental group students to identify their response after the treatment using PBL model.

Before used for data collection, the observation sheet, the test, and the questionnaire were tested to measure the validity and the reliability level. In validation process, the observation sheet and the questionnaire were validated using logic validity while the validity of posttest instrument was measured using empirical validity. The score of logic validity was gathered by having the instruments assessed by the experts for their content and construction validity. It was then counted that all 13 items of observation sheet and all 10 question items of the questionnaire were valid. The score of empirical validity was determined by piloting the instruments. Before piloting the posttest, there were 14 question items high covered these indicators: determining the reactant concentration (5 items), explaining the reaction rate equations (3 items), determining the orders of reaction (1 item), identifying the reaction rate (1 item), and analyzing factors of reaction rate (4 items). The pilot testing result of the posttest question items revealed that out of those question items, there were 2 invalid question items, both of which were in the indicator of determining the reactant concentration. This confirmed that the posttest consisted of the 12 valid question
items. Whereas, the reliability statistics of the instruments was measured by conducting α Cronbach reliability testing assisted by SPSS 22.

Furthermore, the collected data was analyzed using two data analysis techniques. First, the data of observation and posttest were analyzed using MANOVA inferential statistics with the procedures consisted of: 1) formulating the hypothesis, 2) testing of assumptions, and 3) hypothesis testing. The analysis of MANOVA was assisted by SPSS 22. Second, the data of questionnaire was analyzed using descriptive statistics which was assisted by using Microsoft Excel program. The procedures of it included: 1) data tabulation, and 2) percentage computation.

3. Results and discussion

3.1 The effect of applying Problem Based Learning (PBL) model toward students’ conceptual understanding and verbal communication skills

Before taking into the statistical computation, the hypothesis of statistics is formulated as follows:

$H_0$ : There is no significant difference of students’ conceptual understanding and verbal communication skills between those treated using Problem Based Learning (PBL) model and those treated using 5E Learning Cycle model.

$H_a$ : There is significant difference of students’ conceptual understanding and verbal communication skills between those treated using Problem Based Learning (PBL) model and those treated using 5E Learning Cycle model.

The testing of MANOVA applied to test the hypothesis was Hotteling’s Trace testing. The result of analysis is displayed in table 1.

| Value       | F      | Error df | Sig. | Partial Eta Squared |
|-------------|--------|----------|------|---------------------|
| Pillai’s Trace | 0.717  | 75,935b  | 60.00 | 0.000              | 0.717 |
| Wilks’ Lambda | 0.283  | 75,935b  | 60.00 | 0.000              | 0.717 |
| Hotteling’s Trace | 2.351  | 75,935b  | 60.00 | 0.000              | 0.717 |
| Roy’s Largest Root | 2.351  | 75,935b  | 60.00 | 0.000              | 0.717 |

Based on the table, the result of Hotteling’s Trace testing was significantly different in which the significance level (P) was 0.000 < 0.05. The result of statistical analysis rejects the null hypothesis ($H_0$) and confirms the alternative hypothesis ($H_a$). Therefore, the application of applying Problem Based Learning (PBL) model effects positively toward conceptual understanding and verbal communication of senior high school students.

Problem based learning encourage students to make meaning of real-life problem, engage higher order thinking skills, promote problem solving skills, process interdisciplinary learning, develop independent learning, facilitate learning to search for information, apply cooperative learning, and enhance learning of communicative skills [10]. Creative application of PBL aids students to identify, learn, and apply the known concepts from various learning resources and promote self-directed learning which is to be useful for their future needs[11] and contributes to students’ self-actualization.

3.2 The contribution given by PBL model in improving students’ conceptual understanding

To identify the percentage of contribution given by PBL in improving students’ conceptual understanding in reaction rate material, univariate significance testing was conducted. The statistical hypothesis is formulated as follows:

$H_0$ : There is no contribution of Problem Based Learning (PBL) model to improve students’ conceptual understanding.
There is contribution of Problem Based Learning (PBL) model to improve students’ conceptual understanding.

Table 2. The Result of Univariate Testing of Students’ Conceptual Understanding (CU)

| Variabel Dependend | Sum of Squares | Df  | Mean Square | F      | Sig. | Partial Eta Squared |
|---------------------|----------------|-----|-------------|--------|------|---------------------|
| CU                  | 417.330        | 1   | 417.330     | 55.383 | 0.000| 0.476               |

Table 2 that presents the result of univariate testing of students’ conceptual understanding contains the value of partial eta squared. The partial eta squared value is then computed to find out the eta squared which is used to determine the percentage of contribution of the PBL model to improve the conceptual understanding of senior high school students. The percentage of contribution is the quadratic value of partial eta squared multiplied by 100% = \( (0.476)^2 \cdot 100\% \). It was counted that the percentage of the contribution of PBL model in improving students’ conceptual understanding is 22.66% in which the rest percentage of contribution was given by other factors that also take effect to the improvement. This result reveals that PBL effects to students’ conceptual understanding improvement in some way but still in low category of contribution. The low contribution of PBL model is assumedly caused by the fact that the students are not yet accustomed to the application of PBL model in their chemistry class. Further, to test the statistical hypothesis, the univariate testing shows \( F = 55.383, df = 1, \) and \( P = 0.000 < 0.05 \). It indicates the significant difference of students’ conceptual understanding before and after the application of PBL model. It is concluded that the result of statistical analysis confirms the alternative hypothesis \( (H_a) \) stating the positive contribution of PBL model to improve students’ conceptual understanding and rejects the null hypothesis \( (H_0) \).

PBL, which the learning process is conducted by presenting the problem, posing questions related to the problem, facilitating investigation, and opening dialogic working on the problem, demands students’ active engagement to participate. Students are also motivated to be self-directed in constructing their problem-related knowledge for problem solving purpose. The encouragement of students’ active participation on each stage of PBL will affect to the improvement of students’ conceptual understanding. Conceptual understanding refers to students’ abilities to identify the known meaning or concept, situations, and facts [12]. In PBL, such understanding becomes the embodiment of self-constructive, self-explorative, and collaborative process of meaning making which incorporates teacher to facilitate and scaffold learning. Encouraging students to identify problem and the process of problem solving also determines students’ conceptual understanding [13]. PBL model which offers various problem identification process, triggers students to activate their prior knowledge to work on the problem [14] that may leave the students to achieve their proximate development at the end of learning process.

3.3 The contribution given by PBL model in improving students’ verbal communication skills

To identify the percentage of contribution given by PBL in improving students’ verbal communication skills in learning reaction rate material, univariate significance testing was conducted. The statistical hypothesis of this research problem is formulated as the following:

\( H_0 : \) There is no contribution of Problem Based Learning (PBL) model to improve students’ verbal communication skills.

\( H_a : \) There is contribution of Problem Based Learning (PBL) model to improve students’ verbal communication skills.

Table 3. The Result of Univariate Testing of Students’ Verbal Communication Skills (VCS)

| Variabel | Sum of Df | Mean F | Sig. | Partial Eta |
|----------|-----------|--------|------|-------------|
|          |           |        |      |             |
Table 3 presents the partial eta squared value (0.576). The percentage of contribution is the quadratic value of partial eta squared multiplied by 100% = (0.576)^2 x 100%. It was then counted that the percentage of the contribution of PBL model in improving students’ verbal communication skill is 33.17%. The rest of the percentage of contribution was given by other factors that also take effect to the improvement of students’ verbal communication skills. This result reveals that PBL effects to students’ verbal communication improvement but still in mid category of contribution. This is also presumably caused by the fact that the students are not yet accustomed to the application of PBL model in their chemistry class that requires them to articulate their understanding through acceptable verbal communication skills. Afterwards, to test the statistical hypothesis, the univariate testing shows $F = 82.837$, $df = 1$, and $P = 0.000 < 0.05$. It indicates the significant difference of students’ verbal communication skills before and after the application of PBL model in their learning of reaction rate material. In conclusion, the result of statistical analysis confirms the alternative hypothesis ($H_a$) stating the positive contribution of PBL model to students’ verbal communication skills and rejects the null hypothesis ($H_0$).

Verbal communication refers to one’s ability to express the ideas using acceptable words and language function, in both written and spoken form [15]. Being skilled in verbal communication is then emphasized by Sullivan dan Mousley [16] as to not only have the ability to state the ideas in written form, but also in a broader view to articulate, explain, describe, clarify, listen to, question, share, and report the ideas one has got from a learning process. In its process, PBL model has advantageous aspects regarding the enhancement of students’ verbal communication skills. As the students are engaged in a very effective way to work on the problem, students’ verbal communication skills will be developed when they are trying to investigate the problem, arguing theories related to the problem, theorizing their identification of the problem, proposing problem solving, analyzing and evaluating the process of problem solving, and sharing experience related to the process. PBL model, which is able to promote students’ conceptual understanding, will in turn improve their verbal communication skills as on each stage of PBL, the students will posit students to produce various kinds of verbal communication to enunciate their understanding related to the learnt concepts. Other than that, the application PBL model will somehow improve students’ motivation and self-confidence in processing verbal communication. It is, on the very least, due to the fact that the knowledge attained by students at the end of a learning process is their own genuine knowledge contributed by self-directed process of knowledge construction and exploration in PBL model. Having the *weapon* (the attained knowledge) on their own, the students will obviously be more motivated to process and articulate their understanding using well-grounded verbal communication skills.

3.4 Students’ response on the application of PBL model
To identify students’ response on the application of PBL model, the Likert scale questionnaire was analyzed using descriptive statistics, assisted by Microsoft Excel program. The questionnaire was distributed to the students in experimental group to reveal students’ response related to PBL model in two main aspects: 1) students’ response related to learning strategies in PBL model and 2) students’ response regarding the efficacy of applying PBL model to solve problem in the classroom. The result of the analysis of the questionnaire is displayed in Figure 1.
The data analysis of the questionnaire shows that most of the students in experimental group have positive response to the application of PBL model in the classroom. In term of learning strategies of PBL model, the result of data analysis shows students’ high enthusiasm to engage actively in PBL. This finding endorses the theory saying that PBL model turns the learning approach in the classroom from teacher-centered to student-centered learning [17] and results positively to students’ active and independent learning [18]. Dealing with the efficacy of PBL to solve students’ classroom problem, the data analysis also reveals students’ high belief on PBL model. The students have high belief on PBL model that can encourage them to be involved in learning real-life problems, promoting higher order thinking skills, enriching problem-solving skills, encouraging multidisciplinary learning, fostering independent learning, facilitating learning to search for information, supporting cooperative learning, and enhancing learning of verbal communication skills.

4. Conclusion
The quality of learning process is characterized by its ability to bridge students’ knowledge gap, treating students to involve actively in its process. Problem Based Learning (PBL) model, in which the learning is centrally posited to activate and construct students’ knowledge by problem posing and problem-solving activities, contains, in its nature, the promising effect to students’ improvement of conceptual understanding and verbal communication skills in chemistry classes. This study confirms that challenging and engaging students’ self-directed learning of problem-related concepts is able to accelerate students’ conceptual understanding as well as verbal communication skills. It is identified from the findings of this study in which the application PBL model effects positively to students’ conceptual understanding and verbal communication skills (P < 0.05), with the contribution of PBL model to the improvement both variables are, consecutively, 22.66% and 33.17%. However students’ conceptual understanding and verbal communication skill may improve gradually as the result of the precise application and the frequent use of PBL model in classrooms. Other than its advantageous effect for students’ individual development, getting students accustomed to problem-based learning situation will promote students’ cooperative skills in problem solving which is highly prominent in students’ future profesional.

5. References
[1] Kemendikbud. 2007. Peraturan Menteri Pendidikan Nasional Nomor 41 Tahun 2007, tentang Standar Proses.
[2] Slameto. 2013. Belajar & Faktor-Faktor yang Mempengaruhi. (Jakarta: Rineka Cipta).
[3] Sani, A. 2014. The effects of problem based learning on mathematics performance and affective attributes in learning statistics at form four secondary level. Procedia Social and Behavioral Science.
[4] Kek & Huijer. 2017. A Critical Use of Foucault’s Art of Living. Foundations of Science.
[5] Fang, N. 2011. Students’ perceptions of dynamics concept pairs and correlation with their problem – solving performance. J. of sci. technol.

[6] Arnock & Muhammadi. 2016. Language and Individual Identities. Language in India.

[7] Wilder. 2015. Impact of problem-based learning on academic achievement in high school: a systematic review. Educational Review.

[8] Witte & Rogge. 2016. Problem-based learning in secondary education: evaluation by an experiment. Education Economics.

[9] Setiyono. 2011. Pengembangan Perangkat Pembelajaran Kimia Kelarutan Dan Hasil Kali Kelarutan (Ksp) Dengan Pendekatan Sets Untuk Meningkatkan Kemampuan Berpikir Kritis Dan Kreatif Siswa. Jurnal PP.

[10] Creswell, J. 2015. Riset Pendidikan Perencanaan, Pelaksanaan, dan Evaluasi Riset Kualitatif dan Kuantitatif. (New Jersey : Pearson Education, Inc).

[11] Campbell, D. T & Stanley, J. C. 1963. Experimental and Quasi-Experimen Designs for Research. (USA: Houghton Mifflin Company).

[12] Tosun & Taskesenligil. 2013. The effect of problem-based learning on undergraduate students' learning about solutions and their physical properties and scientific processing skills. Chem. Educ. Res. Pract., 2013, 14, 36-50

[13] Yoon, et al. 2016. Professional Development Workshops—What Do Teachers Learn and Use?. J Teach Phys Educ 27 1 116 - 126

[14] Tatar & Oktai. 2011. The effectiveness of problem-based learning on teaching the first law of thermodynamics. Res Sci Technol Educ 29 3

[15] Sungur & Tekkaya 2006. Improving achievement through problem-based learning. J. Biol. Educ. 40 155-160

[16] Schunk. 2014. Handbook of Self-Regulation of Learning and Performance. (New York: Routledge).

[17] Kelly, O. C. & Finlayson, O. E. 2007. Providing solutions through problem – based learning for the undergraduate 1 year chemistry laboratory. Chem. Educ. Res. Pract 8 347 – 361.

[18] Kaya, E. 2013. Argumentation practices in classroom: pre-service teachers’conceptual understanding of chemical equilibrium. Int. J. Sci. Educ 35 1139 – 1158

[19] Tarhan & Ayyildiz. (2018). Problem-based learning in teaching chemistry: enthalpy changes in systems. Res Sci Technol Educ. 36 1 35-55.