Implementation of problem-based learning (PBL) approach to improve student’s academic achievement and creativity on the topic of electrolyte and non-electrolyte solutions at vocational school

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Abstract. The purpose of study was to investigate the implementation of PBL to improve student’s academic achievement and creativity on the topic of electrolyte and non-electrolyte solutions. This study was conducted as a descriptive method with case study design. Subject of this study consisted of 30 students in the class X. Instruments used in the study included tests and observation sheets. Student’s achievement changes is calculated using N-gain formula, hereafter, the data that have been processed then was analyzed descriptively. The results showed that generally academic achievement and creativity of students has increased as indicated by the value of N-gain (0.667; 0.656). The results of the study also showed that there was a correlation with the moderate category between the academic achievement and the student’s creative thinking as indicated by (r = 0.413), meanwhile, the relationship between academic achievement and creativity (r = 0.340) that belongs to the weak category. Implementation of PBL had a good response from students with percentage 80.3%. Based on these findings, PBL is recommended to be applied on the learning process for other chemistry topics that suitable in term of characteristics between learning materials and PBL stages in order to develop academic achievement and creativity of students.

1. Introduction
Creativity of the young generation is needed to build a better Indonesia. Furthermore, creativity is one of the skills that must be owned by the nation's children in the 21st century as a tool to answer the increasingly complex challenges of the future [1]. Paul, Elder, and Bartell suggest that skills in the 21st century are a through description of the disposition of the knowledge and skills aspect, a prerequisite for achieving success in globally competitive in the future[2]. The 21st century learning framework expects 4C skills and innovation as a result of learning, where 4C including critical thinking and problem solving skills, communication skills, collaboration skills, creativity, and innovation skills [3].

In recent, learning approach is believed can affect student’s activities in the process of teaching and learning, therefore research on learning approach continues to be developed by educational experts [4] which states that a learning goal can be achieved effectively with implementation a supports of learning approach. Grady stated that PBL has been widely recognized as one of the approach for effective learning [5]. PBL is a learning approach that has the characteristics to solve problems in
daily life, these characteristics make students learn more actively while developing their potential [6]. PBL is also one of learning approach based on constructivism theory. Problem solving activity in PBL can enhance student’s high-level understanding and thinking skills on learning a subject matter [7].

Related research about PBL has been done [8-17] their studies showed that the implementation of PBL influences student’s activities that have an impact on the mastery concept changes, creativity development, and their attitude as significant. The effect of PBL on student's academic achievement on acid-base material has been conducted [10]. The results showed that the student’s learning achievement of the experimental class using PBL had a significant improvement than students of control class. Based on his results, [10] suggested that research on PBL should be done more broadly by used PBL as an approach that can develop and improve academic achievement. It is an opportunity for researchers to conduct a research on the implementation of PBL to improve student achievement on the topic of electrolyte and non-electrolyte solutions at vocational school.

The formulation of the problem to be studied in this study is "How Implementation of Problem Based Learning to Improve Student’s Academic Achievement and Creativity on the Topic of Electrolyte and Non-Electrolyte at Vocational School?". These general issues are outlined into several specific questions such as (1) how the enhancement academic achievement of high, medium and low group students through the PBL model on the topics of electrolyte and non-electrolyte solutions at vocational school, (2) how the enhancement creativity of high, medium and low group students through the PBL model on the topics of electrolyte and non-electrolyte solutions at vocational school, and (3) how the relationship between academic achievement and creativity through the PBL model on the topics of electrolyte and non-electrolyte solutions at vocational school. The purpose of this study is to analyze the implementation of PBL to improve student's academic achievement and creativity on the topic of electrolyte and non-electrolyte solutions at vocational school.

2. Methods

This study was conducted as a descriptive method with case study design. The qualitative research aims to understand a social phenomenon through a holistic which describes that descriptive qualitative research aims to describe a phenomenon that occurs in the object of research and draw conclusions of these phenomena [18,19].

The subject consisted of 30 students in the class X one of the vocational school in Bandung, they are studying electrolyte and non-electrolyte solutions. The data on this study were collected by test, observation worksheet, guided interview, and questionnaires. Academic achievement changes was calculated based on differences between score pre-test and post-test using N-gain formula. N-gain was obtained from the calculation then translated according to criteria proposed [8] in Table 1.

| N-Gain Score         | Interpretation |
|----------------------|----------------|
| N-Gain > 0.70        | High           |
| 0.30 < N-Gain > 0.70 | Medium         |
| N-Gain < 0.30        | Low            |

The initial stage of this study started by giving the students a pre-test of electrolyte and non-electrolyte solutions, the question of pre-test is 15 questions of multiple choice. 15 items test is divided to four concepts i.e. electrolyte and non-electrolyte, classification of strong and weak electrolyte solution, degrees of dissociation, and ionization reaction. The questions was firstly validated by 5 expert judgments (who work as lecturers and senior chemistry teachers) before used. Based on the validation results the instrument (test questions) was valid. The questions was tested on 30 students of class XI who have done learning about electrolyte and non-electrolyte solution to test the reliability of instrument. Reliability of instrument is calculated by using the Cronbach Alpha (the obtained reliability is 0.82). It is indicated that instrument has a high level of reliability. The second stage of this study is implementation of PBL in learning. Furthermore, in the final stages of this study, students
are given a post-test and a questionnaires (containing student’s responses about the implementation of PBL in learning) to measure their potential development

3. Result and Discussion

3.1 Academic Achievement
The academic achievement of the students was measured using multiple-choice test. The differences in pre-test and post-test score of students are used to describe students' academic achievement after implementation of PBL whether their academic achievement has increased significantly or not. Based on the calculation using the formula N-gain is known that the academic achievement of student generally has increased shown in Figure 1 as bellow:

![Figure 1. Student Achievement as General](image1)

![Figure 2. Student Achievement for each category](image2)

Based on above data can be observed that academic achievement of student generally has increased with high category indicated by N-gain 66 [8]. Besides that the above data also explained that each group has a high N-gain value. N-gain of high group ≤ low group ≤ medium group. Thus, it can be concluded that PBL is one of effective instruction. This is aligned with [8] which states that a good learning approach is able to motivate their students to understand the content of the material that they are studying. PBL is a learning approach that provides a positive impact on increasing student motivation [17]. Besides, the sequence of activities contained in the PBL also plays a role in
improving students' academic achievement [16]. Students activities during implementation of PBL process such as reading, filtering and evaluating various sources of information, assessing others opinions from different perspectives, applying abstract concepts to real situations, finding solutions of problems in groups it has made students more active [20]. Furthermore [21] suggest that student's activity in PBL provide a great opportunity for them to maintain their knowledge over the long term.

Figure 3 below shows that scores for concept of electrolyte & non-electrolyte, classification of strong and weak of electrolyte solution, and degrees of dissociation, generally, more than 75. It indicated that student’s academic achievement has improved. It also indirectly showed the student’s ease of understanding the materials is due to the many phenomenon in daily life related to electrolyte and non-electrolyte solutions that can be directly observed. Besides, the topic of electrolyte and non-electrolyte solution is required experiment activities such an electrical conductivity test. Electrolytes are substances that can ionize and conduct electricity when it dissolved in water [22].

Meanwhile, concept of ionization reaction has low score is caused students difficult to understand that concept it is aligned with the statement [22] which suggests that many students difficult to write the equation of ionization reaction. Besides that, other reasons for the difficulty of ionization reaction come from the Arrhenius acid-base theory and the students who were subjected had not studied the material yet. Acid-base is the basic concept of chemistry [23]. Student of high school who have studied acid-base material said that acid-base is one of the most matters that difficult to understand [24].

![Figure 3. Student Achievement on Each Concepts](image)

3.2 Creativity

Students at top group has greater improvement of creative thinking rather than that of medium and bottom group. According to [25] creative thinking is a high-level thinking process that is identic to problem solving and originality. The creativity of students of top group significantly enhances since they have a stronger basic conceptual understanding than that of medium and bottom group of students, in line with [26] which states that group activities at PBL required students' knowledge and creativity have improved simultaneously. Student’s creativity in generally is already good (80.69%) The improvement of student’s creative thinking for each category class and indicators can be seen in Figure 4 and 5.
3.3 Relationship Between Student’s Academic Achievement and Creativity
There is a correlation between student’s academic achievement and creative thinking has a correlation (0.413). Meanwhile, the relationship between academic achievement and the creative acts has correlation value of 0.340. Furthermore, Taylor and Holland explained that intellectual intelligence only plays a very small role in the determination of one’s creativity, therefore, it is not feasible to be a determinant of creativity. Furthermore Klausmeier and Riple explain that each person has a different level of creativity and the difference is not equivalent to the difference in one's intellectual intelligence.

4. Conclusion
The conclusion of this study is academic achievement and creativity of students generally has increased. Top group of students has greater increased in academic achievement and creativity than that of medium and bottom groups. The implementation PBL in learning received good responses from students.
5. References

[1] Mulyoto 2013 Strategi Pembelajaran di Era Kurikulum 2013 (Jakarta: Prestasi Pelajar)
[2] Germaine R, Richards J, Koeller M and Schubert-Irastorza C 2016 Purposeful Use of 21st Century Skills in Higher Education Journal of Research in Innovative Teaching 9 1
[3] Partnership for 21st Century Skills 2011 21st Century Skills, Education, and Competitiveness http://www.21stcentury.org
[4] Komalasari K 2010 Pembelajaran kontekstual konsep dan aplikasi (Bandung: Refika Aditama)
[5] Báez-González Juan G 2010 Problem Based Learning (Pbl): Analysis of Continuous Stirred Tank Chemical Reactors with s Process Control Approach International Journal of Software Engineering & Applications 1 4 54-73
[6] Overton T L and Randles C A 2015 Beyond problem-based learning: using dynamic PBL in chemistry Chemistry Education Research and Practice 16 2 251-259
[7] Aidoo B, Bouteng S K, Kissi P S and Ofori I 2016 Effect of Problem-Based Learning on Students' Achievement in Chemistry Journal of Education and Practice 7 33 103-108
[8] Abanikamnda M O 2016 Influence of problem-based learning in chemistry on academic achievement of high school students in osun state, nigeria International Journal of Education, Learning and Development 4 3 55-63
[9] Tarhan L and Acar-Sesen B 2013 Problem based learning in acids and bases: Learning achievements and students’ beliefs Journal of Baltic Science Education 12 5 565-578
[10] Belt S T, Evans E H, McCreedy T, Overton T L and Summerfield S 2002 A problem based learning approach to analytical and applied chemistry University Chemistry Education 6 2 65-72
[11] Gallagher S A, Sher B T, Stepien W J and Workman D 1995 Implementing problem-based learning in science classrooms School Science and mathematics 95 3 136-146
[12] Mataka L M and Kowalske M G 2015 The influence of PBL on students' self-efficacy beliefs in chemistry Chemistry Education Research and Practice 16 4 929-938
[13] Overton T L and Randles C A 2015 Beyond problem-based learning: using dynamic PBL in chemistry Chemistry Education Research and Practice 16 2 251-259
[14] Tan O S 2003 Problem-based learning innovation: Using problems to power learning in the 21st century (Thomson Learning Asia)
[15] Benli E and Sarikaya M 2012 The investigation of the effect of problem based learning to the academic achievement and the permanence of knowledge of prospective science teacher: the problem of the boiler stone Procedia-Social and Behavioral Sciences 46 4317-4322
[16] Tosun C and Tapkesenlygyil Y 2012 The effect of problem based learning on student motivation towards chemistry classes and on learning strategies Journal of Turkish Science Education 9 1
[17] Moleong J L 2010 Metode Penelitian Kualitatif (Bandung: PT. Remaja Rosdakarya)
[18] Bungin B 2010 Penelitian Kualitatif: komunikasi, ekonomi, kebijakan publik dan ilmu sosial lainnya (Jakarta: Kencana Prenada Media Group)
[19] Hake R R 1998 Analyzing Change/Gain Scores (USA: Indiana University)
[20] Wood D F 2003 ABC of learning and teaching in medicine: Problem based learning BMJ: British Medical Journal 326 7384 328
[21] Coe A and Jasien P G 1999 An Investigation of Electrolyte Solutions Using a Simple Conductivity Apparatus The Chemical Educator 4 5 171-172
[22] Çetingül İ P and Geban Ö 2005 Understanding of acid-base concept by using conceptual change approach. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi 29 29
[23] Ardej R, Ratanaroutai T, Coll R K and Thongpanchang T 2010 Thai Grade 11 students’ alternative conceptions for acid–base chemistry. Research in Science & Technological Education 28 2 167-183
[24] Tawil M 2013 Berpikir Kompleks dan Implementasi Dalam Pembelajaran IPA
[25] Armitage A, Pihl O and Ryberg T 2015 PBL and Creative Process Journal of Problem Based
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[26] Slameto 1988 Belajar dan Faktor-faktor yang Mempengaruhinya (Bina Aksara)