The effect of learning multimedia on students’ understanding of macroscopic, sub-microscopic, and symbolic levels in electrolyte and nonelectrolyte

Eliyawati1*, I Rohman2 and A Kadarohman2

1International Program on Science Education (IPSE) Study Program, Universitas Pendidikan Indonesia, Bandung, Indonesia
2Chemistry Department, Universitas Pendidikan Indonesia, Bandung, Indonesia.

*Corresponding author’s e-mail: eliyawati@upi.edu

Abstract. This research aims to investigate the effect of learning multimedia on students’ understanding of macroscopic, sub-microscopic, and symbolic levels in electrolyte and nonelectrolyte topic. The quasi-experimental with one group pre-test post-test design was used. Thirty-five students were experimental class and another thirty-five were control class. The instrument was used is three representation levels. The t-test was performed on average level of 95% to identify the significant difference between experimental class and control class. The results show that the normalized gain average of experimental class is 0.75 (high) and the normalized gain average of control class is 0.45 (moderate). There is significant difference in students’ understanding in sub-microscopic and symbolic levels and there is not significant difference of students’ understanding in macroscopic level between experimental class and control class. The normalized gain of students’ understanding of macroscopic, sub-microscopic and symbolic in experimental class are 0.6 (moderate), 0.75 (high), and 0.64 (moderate), while the normalized gain of students’ understanding of macroscopic, sub-microscopic and symbolic in control class are 0.49 (moderate), 0.39 (high), and 0.3 (moderate). Therefore, it can be concluded that learning multimedia can help in improving students’ understanding especially in sub-microscopic and symbolic levels.

1. Introduction
Chemistry is one of the branches of science that studies natural phenomena, especially related to the structure, composition, properties of substances and its changes. Chemistry learning involves the understanding concept among macroscopic, sub-microscopic, and symbolic representation [1]. In addition, chemistry has the number of abstract concepts [2]. Many studies showed that students are not able to understand the abstract concept [1,3,4,5], they are difficult to interpret the representation, explain the verbal explanation, making relationship between multiple representation [1] and linking the representation to chemistry phenomena and chemistry concept [3]. Students’ difficulties to understand the concept of chemistry especially at the sub-microscopic and symbolic levels. It’s because of these levels is invisible and abstract. It can become a problem when it is the key concepts to understand the phenomena. Therefore, to understand chemistry, the teacher should make innovation by providing learning with modeling a macroscopic, sub-microscopic, and symbolic levels of representation [1,4] through make visualization [7].
The efforts that can be done to visualize abstract concept become more concrete are by using instructional media such as multimedia. Multimedia can display text, images, animation, video and audio simultaneously [8]. There are several advantages of using multimedia when compared to other media. It can show many things and many diverse aspects and can create the model that cannot be seen by eye. Learning using multimedia is very effective in helping students visualize chemical processes at the molecular level and recalling memories of facts, concepts or principles [8].

Electrolyte and nonelectrolyte are one topic in chemistry that require abstract concepts. Visualization of this concept allows students to understand of the interactions that occur between particles and chemistry concepts as a whole [3]. However, students’ ability to describe and comprehend such representations seems like what they construct and associate the chemistry content [9]. It need media to visualize the concept of electrolyte and nonelectrolyte. Visualization of this sub-microscopic level is also inseparable from the other two levels of understanding that are the macroscopic and symbolic levels because chemical understanding can be achieved by improving the ability to explain and describe macroscopic, sub-microscopic, and symbolic levels, as well as the ability to connect between the three levels [5].

Based on the above description, it is necessary to develop learning multimedia on the topic of electrolyte and nonelectrolyte. Therefore, the authors examine the effect of learning multimedia on students’ understanding of macroscopic, sub-microscopic, and symbolic levels in electrolyte and nonelectrolyte. The media is expected to make it easier for students to understand concepts at macroscopic, sub-microscopic, and symbolic levels.

2. Methods
Quasi-experimental method is the research method that was used in this study [10]. There was not random assignment of participants to group because the researcher cannot create the artificial experimental group. So, this study required the existing classes. There are two classes that have been already designed, experimental group and control group. Both classes have been given the initial test in the beginning and the final test in the end of learning. The experimental group was given learning with multimedia, while the control group was given learning without multimedia. Seventy students of X grade students in Senior High School were participated in this research. Thirty-five students were in control class and another thirty-five were in experimental class. The instrument that was used is eighteen of achievement test that developed macroscopic, sub-microscopic and symbolic levels in electrolyte and nonelectrolyte topic. Variance test (t-test) using SPSS 16 was performed on the average level of 95% to test the statistical hypothesis through identifying the significant difference of students’ understanding between experimental class and control class in macroscopic, sub-microscopic, and symbolic levels. It needed consideration to analyzing more data, the Sub Microscopic Level data is normally distributed, it used Independent Sample T-Test, while the data of sub-microscopic and symbolic levels are not normally distributed used Mann Whitney U Test.

3. Results and Discussion
Result of students’ comprehension data was obtained by multiple choices that given before learning (pretest) and after learning conducted (post-test). Pretest was given to know students’ prior knowledge, meanwhile, post-test was given to know students’ final knowledge about electrolyte and nonelectrolyte in three levels representation (macroscopic, sub-microscopic and symbolic levels). The differences result that already obtained from experimental and control classes are shown in Figure 1.
The criterion of students’ understanding as a whole can be analyzed through learning results. Both classes get difference mean in pretest and post-test. In pretest, mean in experimental class is 43.97, while in control class is 45.97 (figure 1). Furthermore, we need statistical analysis to know significant difference condition of their prior knowledge. The t-test was measured and showed the result of Sig.(2-tailed) > 0.05. It means the prior knowledge of students between experimental and control class is homogeneous. The prior knowledge is important to acknowledge the difference relevance to student achievement and bridging the gap between teachers’ expectations and students' actual knowledge base [11]. The average of % normalized gain was measured to know the criterion quality of students’ understanding. Both classes get difference % normalized gain, 75 for experimental class which categorize as high criterion and 45 for control class which categorized as moderate criterion. It means that the criterion of students’ understanding in experimental class is better than control class.

The criterion of students’ understanding in macroscopic, sub-microscopic and symbolic levels have already measured using the value of normalized gain. These three levels of understanding are distributed on test results of learning about electrolyte and nonelectrolyte in Figure 2.

![Figure 1. Student’s understanding results](image)

![Figure 2. The average of normalized gain macroscopic, Submicroscopic, and symbolic levels.](image)
in microscopic level (molecular understanding) while in the control class, the highest normalized gain average is in macroscopic level. This result is same with other research that stated the students who learned chemical phenomena using multimedia instruction outperformed and could represent the concept at molecular level [8]. If we compare n-gain between macroscopic and sub-microscopic level, the sub-microscopic n-gain is higher than macroscopic n-gain. This result is different with other research that showed the understanding of macroscopic level is higher than sub-microscopic level [4].

3.1. Macroscopic Level

The macroscopic level is a truly observable chemical phenomenon. A statistical test of the gain data of macroscopic level is obtained to see the difference understanding of the macroscopic level between experimental class and the control class. The statistical test performed using 95% confidence level, so that the value of $\alpha = 0.05$. The requirement of a data is called normal if the probability or p (Sig.) > 0.05, since p (Sig.) of normality test in experimental class and control class <0.05, then it means the data is not normally distributed. Therefore, Test Mann Whitney U was used to test significant difference. The test results can be seen in Table 1.

| Test                | Macroscopic |
|---------------------|-------------|
| Mann-Whitney U      | 516.500     |
| Wilcoxon W          | 1146.500    |
| Z                   | -1.187      |
| Asymp. Sig. (2-tailed) | .235       |

Asymp Value. Sig (2-tailed) = 0.235; because Asymp. Sig (2-tailed)> 0.05 (table 2) then H0 is accepted, so it is evident that there is no significant difference in students’ understanding of macroscopic level between experimental and control class. The normalized gain average of the experimental class is greater than the control class (figure 2), but they still have the same criterion which is moderate criterion. This is due to the lack of maximum role of the video conducting test of electrical conductivity in terms of understanding the macroscopic level of the students. There is a less clear recorded phenomenon that is the difference between a strong electrolyte and weak electrolyte and the appearance of the phenomenon of the emergence or absence of gas bubbles around the electrodes is less observable.

3.2. Sub-Microscopic Level

The normalized gain (n-gain) average of the experimental class is greater than the control class (figure 2). The average value of n-gain in the experimental class is classified as high criterion that is 0.75, while the average n-gain value in the control class is moderate criterion that is 0.39. The statistical tests performed consist of normality and significance test. Since p (Sig.) of normality test in experimental class and control class > 0.05, then it means the data is normally distributed. Therefore, parametric data analysis is done using Independent Sample T-test to know the difference of understanding of microscopic level between control class and experiment class. The results of the Independent Sample T-test can be seen in Table 2.
Table 2. Significant difference Test of Students’ Understanding in Sub-Microscopic Level

| Levene's Test for Equality of Variances | t-test for Equality of Means | 95% Confidence Interval of the Difference |
|----------------------------------------|-----------------------------|----------------------------------------|
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Equal variances assumed | .581 | .449 | -3.494 | 68 | .001 | -14.85714 | 4.25197 | -23.341 | -6.372 |
| Equal variances not assumed | -3.494 | 67.421 | .001 | -14.85714 | 4.25197 | -23.343 | -6.371 |

The t count value of the experimental class and control class is [-3.494] with p value (Sig. (2-tailed)) = 0.001. The value of t count> t table (t table is 1.995) and p (Sig. (2-tailed)) <0.05; So H0 is rejected. It means that there is a significant difference of students’ understanding in sub-microscopic level between experimental class and control class. Increasing students’ understanding of sub-microscopic level can be seen from the normalized gain average. It turns out that the normalized gain average of experimental class is greater than control class. The findings of the study are in accordance with the opinions that analogy an abstract concept becomes more concrete, not only necessary verbal words but required a medium that can reveal the microscopic level [6]. The reason why the verbal words are not enough to analogize the sub-microscopic level is that the students’ imaginations may vary and cannot be controlled. In addition, verbal explanations in chemical processes can produce difference translations that can potentially lead to misconceptions. Because of these reasons, it is necessary a multimedia that can increase students’ understanding of sub-microscopic level and minimize student misconception. Sub-microscopic means the understanding at molecular level. The students outperformed on understanding at molecular level using multimedia instruction [8].

3.3. Symbolic Level

The last level that is not less important is the symbolic level. This level concerns the symbols or symbols used to define macroscopic and microscopic level phenomena. It is found that the average of n-gain of the experimental class is greater than the control class, but the two classes have an average of n-gain included in the moderate criterion. The statistical test was measured and its resulted the p value (Sig.) <0.05, the data is not normally distributed. Therefore, Mann Whitney U Test was performed to analyze the significant difference. Mann Whitney U Test Result can be seen in Table 3.

Table 3. Significant difference Test of Students’ Understanding in Symbolic Level

| Test | Symbolic |
|------|----------|
| Mann-Whitney U | 378.500 |
| Wilcoxon W | 1008.500 |
| Z | -2.810 |
| Asymp. Sig. (2-tailed) | .005 |

Asymp value. (2-tailed) = 0.005. Asymp. (2-tailed) <0.05; H0 is rejected. It means that there is a significant difference of students’ understanding of symbolic level between experimental class and control class. This level is no less important than the macroscopic or microscopic level. The result of the difference test shows that there is significant difference students’ understanding of the symbolic level between experimental and control class. The acquisition of learning results through the sense of view is greater than the other senses, but many students have difficulty learning symbolic level.
However, the fact in the experimental class seems to understand the symbolic level is very easy. This is not independent of the role of multimedia that can explain the level of symbolic understanding and interrelationship with other levels.

4. Conclusion
Based on explanation above we can conclude that learning multimedia can increase students understanding. The % normalized gain for experimental class is 75 which categorized as high criterion and 45 for control class which categorized as moderate criteria. There is significant difference of students’ understanding of sub-microscopic and symbolic level and there is no significant difference of students’ understanding of macroscopic level between experimental class and control class. The normalized gain of students’ understanding of macroscopic, sub-microscopic and symbolic in experimental class are 0.6 (moderate), 0.75 (high), and 0.64 (moderate), while the normalized gain of students’ understanding of macroscopic, sub-microscopic and symbolic in control class are 0.49 (moderate), 0.39 (high), and 0.3 (moderate). Therefore, it can be concluded that learning multimedia can help in improving students’ understanding especially in sub-microscopic and symbolic levels. The findings of this study can be used for further research to investigate how chemistry is learned and taught through learning multimedia, so the students can understand chemistry concept completely through understanding three level of chemical representation and connect it each other.

5. References
[1] Wu H K, Krajcik J S and Soloway E 2001 Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom Journal of research in science teaching 38 7 21-842
[2] Gilbert J K 2005 Visualization: A metacognitive skill in science and science education Visualization in Science Education (Germany: Springer Dordrecht)
[3] Rahayu S and Kita M 2010 An analysis of indonesian and japanese students' understandings of macroscopic and submicroscopic levels of representing matter and its changes International Journal of Science and Mathematics Education 8 4 667-688
[4] Raviolo A 2001 Assessing students' conceptual understanding of solubility equilibrium Journal of Chemical Education 78 5 629
[5] Treagust D, Chittleborough G and Mamiala T 2003 The role of submicroscopic and symbolic representations in chemical explanations International Journal of Science Education 25 11 1353-1368
[6] Wu H K 2003 Linking the microscopic view of chemistry to real- life experiences: Intertextuality in a high- school science classroom Science Education 87 6 868-891
[7] Hailikari T, Katajavuo N and Lindblom-Ylanne S 2008 The relevance of prior knowledge in learning and instructional design American Journal of Pharmaceutical Education 72 5 113
[8] Ardac D and Akaygun S 2004 Effectiveness of multimedia- based instruction that emphasizes molecular representations on students' understanding of chemical change Journal of research in science teaching 41 4 317-337
[9] Cook M., Wiebe E N and Carter G 2008 The influence of prior knowledge on viewing and interpreting graphics with macroscopic and molecular representations Science Education 92 5 848-867
[10] Creswell J W 2002 Educational research: Planning, conducting and evaluating quantitative (Upper Saddle River NJ: Prentice)
[11] Kozma R 2003 The material features of multiple representations and their cognitive and social affordances for science understanding Learning and Instruction 13 2 205-226

Acknowledgments
We acknowledged IPSE Study Program and Chemistry Department Universitas Pendidikan Indonesia, also Putra Sampoerna Foundation Scholarship from Sampoerna Foundation Indonesia.