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Dynamic Representation-Aided Discovery Learning to Improve Translational Ability between Different Representations at the Same Level

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Abstract: This research aimed to describe the effectiveness of discovery learning assisted by molecular simulations in improving translational ability at the same level on stoichiometric topic. The method used in this research was quasi-experimental with purposive sampling data collection techniques. The population in this study were all eleventh graders at SMA Negeri 2 Metro for the 2022/2023 academic year. This study applied XI IPA 2 as the experimental class and XI IPA 3 as the control class. Increasing in translational ability at the same level was measured based on the significant difference in the n-gain average in the experimental class and the control class. The research results showed that the n-gain average of students in the experimental class was 0.6 in high criteria, while the n-gain average of students in the control class was 0.53 in medium criteria. Based on the difference test, the translational ability at the same level of students in the experimental class was higher than in the control class. It can be concluded that discovery learning assisted by molecular simulations was effective in improving translation abilities at one level of chemical representation in stoichiometric topic.

Keywords: discovery learning, molecular simulation, translation ability at one level chemical representation, stoichiometry.

▪ INTRODUCTION

Chemistry is often considered a difficult subject to teach and learn. Most chemistry exists at the molecular level so chemistry is abstract. The abstract characteristics of chemistry make it seem unrelated to everyday life (Johnstone, 2000; Kozma & Russell, 1997; Shehab & BouJaoude, 2017). Concepts in chemistry and the abstractness therein can be understood with chemical representation-based learning (Sunyono, 2013). The three domains of chemical representation are depicted in the corners of an equilateral triangle, where they are equal and complementary, namely macroscopic, symbolic and submicroscopic (Johnstone, 1991; Johnstone, 2000). Students' understanding of the role of each level of macroscopic, symbolic and submicroscopic representation as well as the relationship between each level must be used by chemistry teachers simultaneously (Treagust et al., 2003). The macroscopic level refers to what can be observed and touched, the submicroscopic level refers to what happens at the molecular level and the symbolic level refers to how a phenomenon is symbolized (Gkitzia et al., 2011; Johnstone, 2000).

One of the representational abilities according to Kozma and Russell (2005) is the ability to translate between different representations at the same level. This chemical representational ability is very important for students in studying chemistry. If students experience difficulties in one of the three levels of chemical representation or experience confusion between the three levels, it can interfere with subsequent chemistry learning

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(Sim & Daniel, 2014). Misconceptions in chemistry come from students' inability to understand the three levels of chemical representation (Tasker & Dalton, 2006).

One of the topics in chemistry subjects that requires representation-based learning is Stoichiometry. In studying the concept of stoichiometry, students should understand phenomena at the molecular level through imagination from the realm of chemical representation (Sujak et al., 2017). Chemistry learning that only focuses on calculations will result in a lack of conceptual understanding (Dahsah & Coll, 2008). One medium that can be used to apply the use of chemical representations is learning chemistry using simulations.

Simulations are essential for linking various chemical representations (Treagust 2003). Computer-based molecular simulation is a technique used to interpret experimental data at the molecular level (Vangusteren, 2003). Molecular simulations can visualize molecules at the submicroscopic level (Meir et al., 2005). In this case, a simulation called the Connected Chemistry Curiculum is used, which is a project from The Stieff Lab at the University of Illinois at Chicago, and a PhET simulation developed by a group of researchers from the University of Colorado at Boulder in the United States. These two simulations can explain the concept of stoichiometry, especially the concept of reaction equations and limiting reactions. The Connected Chemistry Curiculum simulation helps students and teachers visualize how a substance/molecule can react to produce a new substance/molecule.

Using animation or simulation effectively requires directing students' attention to focus, avoiding excessive working memory, and introducing material by linking previous knowledge. This can be done by using a constructivist learning model that exploits knowledge about how students learn (Tasker & Dalton, 2006). The appropriate learning model for integrating molecular dynamics simulations is the discovery learning model (Bicknell-Holmes & Hoffman, 2000; Castronova, 2002). Discovery learning includes instructional models and strategies that focus on activeness and learning opportunities for students (Castronova, 2002). The stages in the discovery learning model are (a) Stimulation (providing stimulation); (b) Problem Statement (problem identification); (c) Data collection (data collection); (d) Data Processing (data processing); (e) Verification (proof); and (f) generalization (drawing conclusions).

The results of research conducted by (Stieff, 2011) show that the use of the Connected Chemistry Curiculum simulation has the potential to increase students' chemical representation competence, students tend to answer questions by connecting the three levels of chemical representation, especially the submicroscopic level. Tasker & Dalton (2006) also conducted research on the use of m-simulation in improving students' mental models. The research results show that animation and simulation are effective in increasing understanding at the molecular level.

This research aims to describe the effectiveness of discovery learning assisted by molecular simulations in improving students' translational ability at the same level of chemical representation on the topic of stoichiometry.

▪ METHOD

The population in this study were all class The samples in this study were X IPA 2 as an experimental class with a total of 33 students consisting of 23 male students and 10 female students and The technique for selecting samples used purposive sampling.

The method used in this research was a quasi-experimental with the matching-only pretest-posttest control group design. The pretest results of these two samples were then matched statistically through a test of equality of two means. In the control class, the discovery learning model is applied. In the experimental class, treatment was given in the form of a discovery learning model assisted by molecular simulation. The simulations used were Connected Chemistry Curriculum (ConnChem) and PhET Simulation. At the end of the lesson, samples were given a posttest to test chemical representational abilities. The Learning was carried out in 3 meetings. In the experimental class discovery learning assisted molecular simulation wass applied while in the control class used discovery learning. The discovery learning model consists of 6 stages, namely stimulation (providing stimulation), problem statement (problem identification), data collection (data collection), data processing (data processing), verification (proof), generalization (drawing conclusions).

The instruments in this research were pretes-postest and the observation sheets for the implementation of the discovery learning model. Both instruments have been content validated through experts judgment in chemistry learning. The effectiveness of discovery learning assisted by molecular simulations in improving translational ability at the same level is measured by the significant difference in n-gain between the control class and the experimental class using the t-test with the test criteria: accept H_0 if the sig (2-tailed) result is> 0.05 and accept H_1 if the result is sig(2-tailed) <0.05.

▪ RESULT AND DISCUSSION

Discovery learning carried out in the experimental class used molecular simulations. The simulations was from the Connected Curriculum website and PHET simulation. The examples of the simulation display can be observed in Figures 1 and 2.

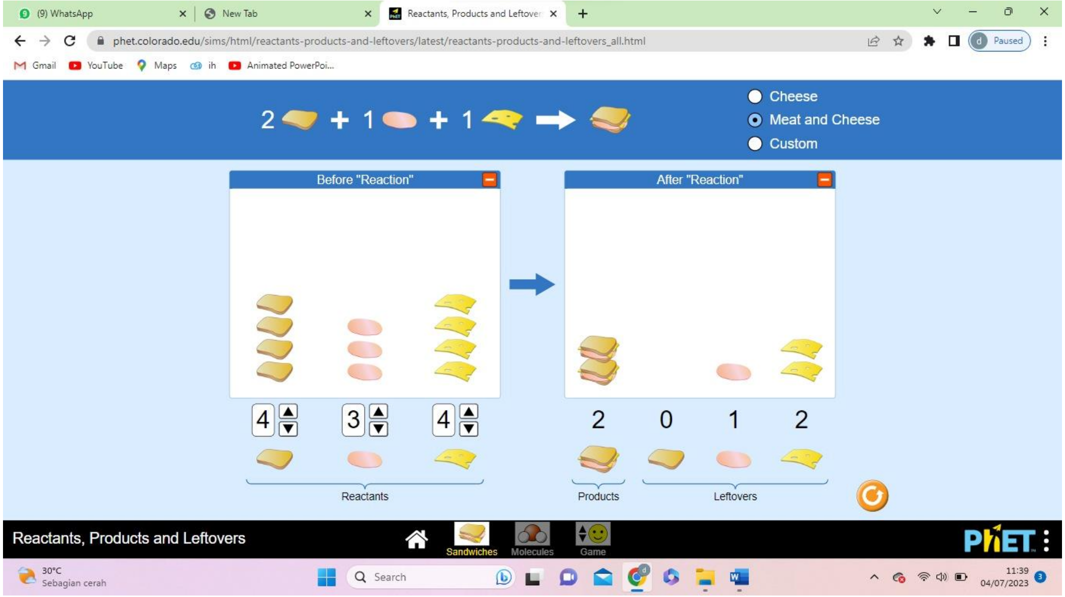


Figure 1. PhET application of the limiting reagent stimulation

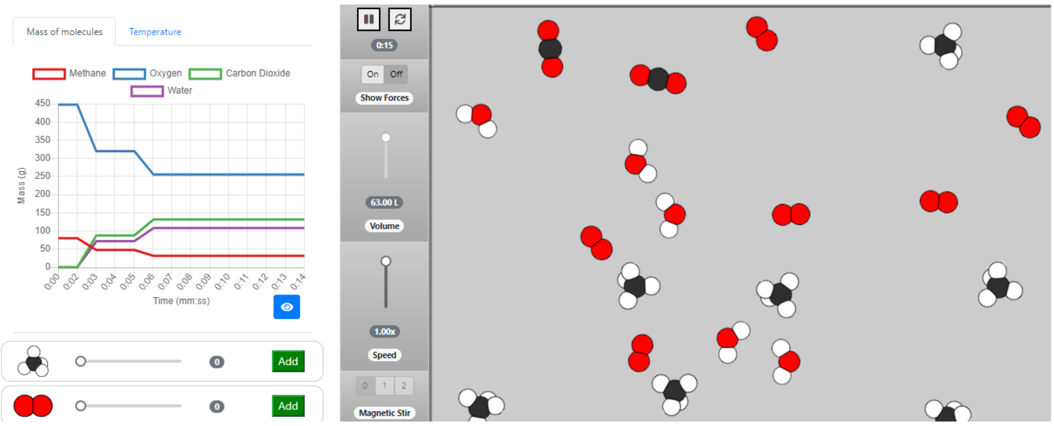


Figure 2. Methane combustion reaction in the ConnChem simulation

Data on pretest, posttest and n-gain results from the control and experimental classes can be seen in table 1.

Class	**Pretest**		**Postest**		**n-gain**	
	N	***Mean***	**N**	***Mean***	**N**	***Mean***
Control	33	15.55	33	57.24	33	0.40
Experiment	33	15.56	33	70.55	33	0.65

The pretest scores obtained for the experimental class and the control class were almost the same. Then a test for equality of two means is carried out, but before carrying out a test for equality of two means a normality test and homogeneity test are carried out. This test was carried out using SPSS version 25.0. Based on the test results, it was found that the data was normally distributed and had a homogeneous variance, so that the test for equality of two averages used the Independent Samples T-test and obtained a sig value. (2-tailed) is 0.946, so when compared with α, the result is sig > 0.05, then H0 is accepted. Therefore, it can be concluded that both samples have translation capabilities at the same level of representation. The distribution of n-gain values in the control and experimental classes is presented in Figure 3.

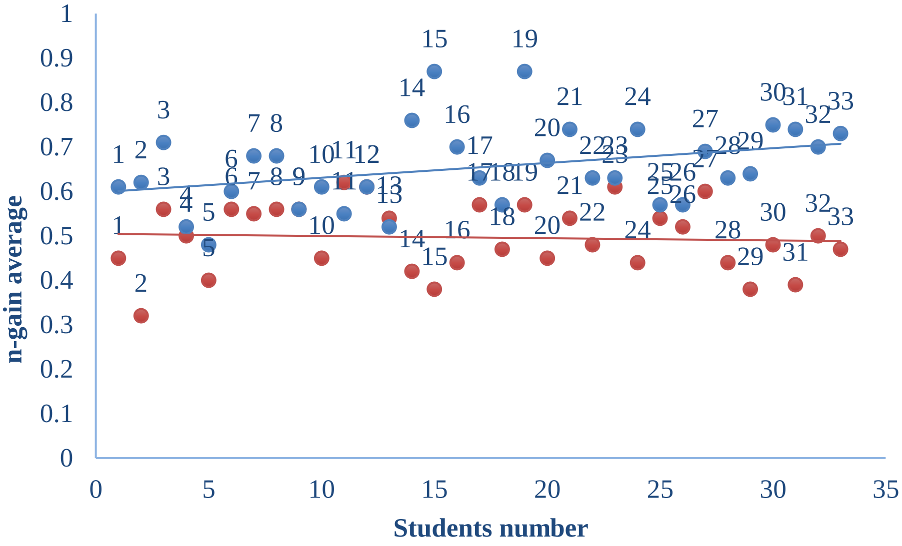
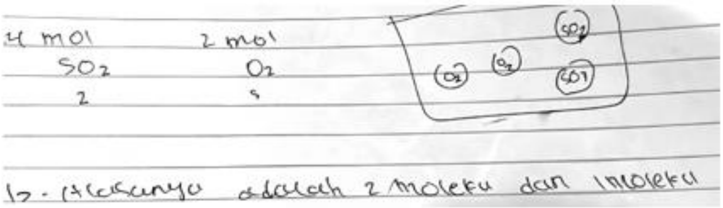
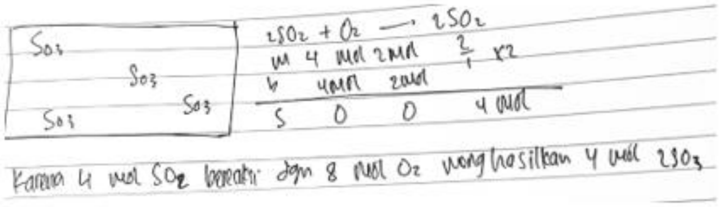


Figure 3. Distribution of n-gain values translational ability at the same level

There was an increase in translational ability at the same level of students in the experimental class which used a discovery learning model assisted by molecular simulation which was higher than the increase in translation ability between levels of chemical representation in the control class which used a discovery learning model. Test the difference between two means using the t test, namely the independent samples t-test because the data obtained is normally distributed and homogeneous, the test uses SPSS version 25.0. The significance value is 0.005 when compared with α, the result is Sig > 0.05, then H1 is accepted. So it can be concluded that the average n-Gain value of translational ability at the same level of students in the experimental class is greater than the average value of n-Gain of translational ability at the same level of students in the control class on stoichiometric material. Therefore, it can be concluded that the discovery learning model assisted by molecular simulations on stoichiometric material is effective in improving students' translational ability at the same level. The examples of student pretest and posttest answers can be seen in Figure 4.



Pretest



Postest

Figure 4. example of students' answer in pretes and postes

In the pretest answer number 1a, student 1 rewrote the question that had been given and described the representation incorrectly, but in the posttest answer the student answered correctly and was able to describe the representation correctly. In pretest number 1b, in the pretest answer, the student gave an incorrect reason because he calculated incorrectly, and for the posttest answer, the student was able to answer the question correctly because he could calculate well.

▪ CONCLUSION

The discovery learning model assisted by molecular simulation is effective in improving translational ability at the same level on the topic of stoichiometry. The results of this study are very useful for teachers in teaching chemical concepts, especially concepts that require sub-micro representational reasoning and improving students' representational competence. For researchers, the results of this study provide an opportunity to examine the use of molecular simulations in other chemistry topics and compare the effectiveness of static and dynamic representations.

▪ REFERENCES

Bicknell-Holmes, T., & Seth Hoffman, P. 2000. Elicit, engage, experience, explore: Discovery learning in library instruction. Reference Services Review, 28(4), 313–322.

Castronova, J. A. 2002. Discovery Learning for the 21st Century: What is it and how does it compare to traditional learning in effectiveness in the 21st century. Action Research Exchange, 1(1).

Dahsah, C., & Coll, R. K. 2008. Thai grade 10 and 11 students' understanding of stoichiometry and related concepts. International Journal of Science and Mathematics Education, 6(3), 573–600.

Gkitzia, V., Salta, K., & Tzougraki, C. 2011. Development and application of suitable criteria for the evaluation of chemical representations in school textbooks. Chemistry Education Research and Practice, 12(1), 5–14.

Johnstone, A. 1991. Why is chemistry difficult to learn? things are seldom what they seem. Journal of Computer Assisted Learning, 7(1), 75–83.

Johnstone, A. H. 2000. the Practice of Chemistry Education (Invited Contribution*). Chemistry Education: Research And Practice In Europe Educ. Res. Pract. Eur, 1(1), 9–15.

Kozma, R. B., & Russell, J. 1997. Multimedia and Understanding: Expert and Novice Responses to Different Representations of Chemical Phenomena. Journal of Research in Science Teaching, 34(9), 949–968.

Kozma, R., Chin, E., Russell, J., & Marx, N. 2000. The Roles of Representations and Tools in the Chemistry Laboratory and Their Implications for Chemistry Learning Center for Technology in Learning SRI International. The Journal of the Learning Sciences, 9(2), 105–143.

Kozma, R., & Russell, J. 2005. Students Becoming Chemists: Developing Representationl Competence. Visualization in Science Education, 121–145.

Meir, E., Perry, J., Stal, D., Maruca, S., & Klopfer, E. 2005. Article How Effective Are Simulated Molecular-level Experiments for Teaching Diffusion and Osmosis ? 4, 235–248.

Shehab, S. S., & BouJaoude, S. 2017. Analysis of the Chemical Representations in Secondary Lebanese Chemistry Textbooks. International Journal of Science and Mathematics Education, 15(5), 797–816.

Sim, J. H., & Daniel, E. G. S. 2014. Representational competence in chemistry: A comparison between students with different levels of understanding of basic chemical concepts and chemical representations. Cogent Education, 1(1), 1–17.

Stieff, M. 2011. Improving representational competence using molecular simulations embedded in inquiry activities. Journal of Research in Science Teaching, 48(10), 1137–1158.

Sujak, K. B., Gnanamalar, E., & Daniel, S. 2017. Understanding of Macroscopic, Microscopic and Symbolic Representations among Form Four Students in Solving Stoichiometric Problems. Malaysian Online Journal of Educational Sciences, 5(3), 83–96.

Sunyono. 2013. Validitas Model Pembelajaran Kimia Berbasis Multipel Representasi Untuk Meningkatkan Model Mental Siswa Pada Topik Struktur Atom. Journal of Chemical Information and Modeling, 53(9), 1689–1699.

Tasker, R., & Dalton, R. 2006. Research into practice: Visualisation of the molecular world using animations. Chemistry Education Research and Practice, 7(2), 141

Treagust, D. F., Chittleborough, G., & Mamiala, T. L. 2003. The role of submicroscopic and symbolic representations in chemical explanations. International Journal of Science Education, 25(11), 1353–1368.

Vangunsteren, W. F., Dolenc, J., & Mark, A. E. 2008. Molecular simulation as an aid to experimentalists. Current Opinion in Structural Biology, 18(2).