# Development of Guided Inquiry based E-Learning Teaching Material on the Intermolecular Forces Enriched with Molview

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**Abstract**

The intermolecular force is one of the chemistry topics covered in the high school curriculum in Indonesia. As the characteristics of chemistry concepts in general, intermolecular forces concepts can be presented in the three levels of chemical representations (microscopic, symbolic, and macroscopic). Currently, chemistry teaching materials are available in Indonesian schools mostly have limited support for helping students to visualize the molecular aspect of intermolecular forces concepts mainly in the form of three-dimensional space (3D). This study aimed to produce an E-Learning teaching material enriched with 3D Molecular Visualization. The product (teaching material) in this study is presented by considering the syntax of guided inquiry-based learning. The product was developed with the procedure adopted from Lee & Owens, including assessment/analysis, need assessment, front-end analysis, design, and development. The product is valid and suitable to be applied in online chemistry teaching. However, further study to investigate the effectiveness of this product empirically need to be explored in the future.

## I. Introduction

Chemistry is one of the subject for the school curriculum at the senior high school [9]. Chemistry has several characteristics, one of them is the abstract concept of chemistry which makes chemistry difficult to be understood [1]. Chemistry is studied through three levels of representation including the microscopic, symbolic, and macroscopic levels [12], the transition between the three levels, especially at the macroscopic level to the microscopic level, is necessary for students to develop an understanding of chemical knowledge [11]. The transition of microscopic representations to explain material at the molecular level that cannot be seen directly and is not easily visualized by students makes chemical material often difficult [10].

Chemical materials which contains quite a lot of microscopic aspects, one of them is the intermolecular forces. The subject of intermolecular forces study the london force, induced dipole forces, dipole-dipole forces, hydrogen bonds, and the effect of intermolecular forces on physical properties which contain more microscopic representations [7]. The results of researchers' observations of the teaching materials applied by teachers to students still use textbooks and the minimal application of technology to the learning process. This causes students to have difficulty in learning the intermolecular forces of matter.

In essence, teaching materials have a big influence in adding and increasing learning effectiveness [8], so it is necessary teaching materials are varied, especially technology-based as a supporting medium for more interactive learning process, one of them is E-Learning which can be used as supporting teaching materials for students in deepening the topics they learn. The diversity of features that E-Learning has is to make E-Learning suitable for deepening the topic of intermolecular forces which contain three levels of chemical representation. Adequate learning access speed and learning interactions that can be done asynchronously as well as the completeness of the features makes E-Learning become very suitable to be applied in the learning process asynchronously, especially during the COVID-19 era. In addition, the E-Learning system can make learning chemistry easier because it is flexible and many features available, but to maximally to learn about microscopic level there need the addition material like Molview.

This Molview application can help to visualize the parts of the molecule that experience intermolecular forces in 3D [5], besides that, a learning model is also needed in the preparation of material content and features according to the syntax used. One learning model that is suitable to be applied in E-Learning and the topic of intermolecular forces is a guided inquiry learning model that can increase the participation of students in constructing the concept of intermolecular forces. The appearance of teaching materials in E-Learning on the topic of intermolecular forces is made according to the syntax of guided inquiry stages according to [2], namely: orientation, exploration, concept formation, application, and closure.

## II. Method

The E-Learning teaching material development model uses the research and development model proposed by [4] to develop multimedia. This model has the advantage of having a systematic and clear sequence of steps. Lee & Owens development model which consists of five steps, namely (1) assessment / analysis which includes needs assessment and front-end analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. In the process of developing this teaching

material, it only reaches the development stage. Assessment and analysis are carried out to outline what components are needed in the development and their limitations. The process of needs analysis is carried out by literacy studies, field studies, and non-formal interviews in the form of a question and answer process to students in several public high schools in Malang regarding on tenth grade's chemistry materials are difficult to understand and chemical teaching materials that have been used by teachers in the learning process chemistry. The initial-final analysis stage aims to obtain complete analytical data from preparation to post-production of product development. The design step consist of story board. The development consists of two activities, namely the production step and the post-production step.

At the production step, E-Learning teaching materials began to be developed from the initial appearance to the complementary display of each subtopic. After the production step is complete, the next step is the post-production stage where the teaching materials developed are validated by experts. Validators are chosen according to the development of teaching materials, namely validators who are experts in intermolecular forces and understand how to use E-Learning. The results of validation can be on the form of quantitative data and qualitative data in the form of suggestions and comments as a consideration for revision so that teaching materials can be better.

Student's learning activities in E-Learning on the intermolecular forces enriched with molview followed the step of guided inquirt in the teaching material, that based on student's center. They can explore the material with complete with picture, video, and moleview for eassier the students. Data collection uses an instrument in the form of a questionnaire equipped with a checklist in several aspects needed and there is a comment and suggestion column as an evaluation of the teaching materials presented in the google form. Likert scale scores 1-5 were used in the assessment of this questionnaire. Trial subjects can add a checklist to the scale for assessment according to the criteria presented in table 1 below.

Tabel 1.

Likert Scale Rating Rules for Teaching Materials

| **Information** | **Score** |
|---|---|
| Very Good / Very Worthy / Very Interesting / Very Clear (SB) | 5 |
| Good / Proper / Attractive / Clear (B) | 4 |
| Good Enough / Fair Enough / Interesting Enough / Self-explanatory (C) | 3 |
| Unfavorable / Inadequate / Less Attractive / Less Clear (K) | 2 |
| Very Poor / Very Poor / Very Less Attractive / Very Less Clear (SK) | 1 |

The quantitative data obtained from the validation and legibility tests are then analyzed based on the percentage calculation with the following formula.

$$\text{PPV} = \frac{Xi}{Xm}$$

Notes:

PPV = Percentage of Validator Ratings

*Xi* = Total number of validator ratings

*Xm* = The total number of the highest validator scores

The result of the average percentage score of the validator is used to determine the validity of the teaching material. The percentage rate shows the feasibility level of the development product made, the higher the value, the better the feasibility. Table 2 presents the feasibility level of the percentage analysis of the product developed.

Tabel 2.

Percentage Analysis Eligibility Criteria

| **Percentage (%)** | **Information** |
|---|---|
| 0-20 | Not feasible |
| 21-40 | Not worth it |
| 41-60 | Decent enough |
| 61-80 | Well worth it |
| 81-100 | Very worthy |

## III. Results and Discussion

The results obtained from the development of this teaching material are qualitative and quantitative data. Qualitative data were obtained from suggestions and comments, while quantitative data were obtained from assessments using a Likert scale. This data was obtained from the results of validation by both material and media validators, as well as from the results of the readability test conducted by 30 students. The results of the validation by material experts was carried out by one chemistry lecturer and two teachers from SMAN 1 Genteng and MAN 1 Malang got a very decent category with a percentage of 85.58% with detailed criteria presented in table 3.

Table 3.

Material Expert Quantitative Data Presentation

| Criteria | % | Information |
|---|---|---|
| Aspects of Presenting Basic Competencies (KD) & Learning Objectives | 93.34 | Very Worth it |
| Concept Map Presentation Aspects | 93.34 | Very Worth it |
| Presentation Aspects Introduction and Introduction | 73.35 | Well worth it |
| Aspect Sub-topic I: Concept of London Style | 80.74 | Very Worth it |
| Aspect Sub-topic II: Concept of Induced Dipole-Dipole Force | 76.30 | Well worth it |
| Aspect Sub-topic III: Dipole-dipole Style Concept | 80.03 | Well worth it |
| Aspect Sub-topic IV: Concept of Hydrogen Bonding | 78.52 | Well worth it |
| Aspect Sub-topic V: Concept of Effect of Intermolecular Forces on Physical Properties of Matter | 77.78 | Well worth it |
| Presentation Aspects of the Final Quiz | 80 | Well worth it |
| The Truth Aspect of the Concept of Intermolecular Force | 100 | Very Worth it |
| **Average** | **85.58** | **Very Worth it** |

The results of qualitative data from material experts were obtained from suggestions and comments in the assessment questionnaire via google form that had been given to the speaker. Qualitative data of material experts can be seen in table 4.

Table 1.

Qualitative Data Presentation on Material Validation Results

| Validator | Suggestions and Comments |
|---|---|
| **1** | Inquiry is more visible with an inductive approach. |
| **2** | Broadly speaking, the material display and the explanation stage are good using a lot of literacy that is used. |
| **3** | The appearance is attractive and overall good. Long videos can be replaced with shorter ones so students don't get bored. |

The results of the validation by media experts conducted by one chemistry lecturer and two teachers from SMAN 1 Genteng and MAN 1 Malang received a very feasible category with a percentage of 83.34% with detailed criteria presented in table 5.

Table 2.

Presentation of Quantitative Data for Media Experts

| Criteria | % | Information |
|---|---|---|
| Introductory Aspects and Introduction to Topics | 86.67 | Very Worth it |
| Aspects of Ease of Access to E-Learning | 86.67 | Very Worth it |
| Aspects of the Concept of Intermolecular Force | 85 | Very Worth it |
| Aspect Sub-topic I: Concept of London Style | 80.56 | Very Worth it |
| Aspect Sub-topic II: Concept of Induced Dipole-Dipole Force | 83.34 | Well worth it |
| Aspect Sub-topic III: Dipole-dipole Style Concept | 82.78 | Well worth it |
| Aspect Sub-topic IV: Concept of Hydrogen Bonding | 81.67 | Well worth it |
| Aspect Sub-topic V: Concept of Effect of Intermolecular Forces on Physical Properties of Matter | 84.85 | Well worth it |
| Presentation Aspects of the Final Quiz | 88.89 | Very Worth it |
| **Average** | **83.34** | **Very Worth it** |

The results of qualitative data from media experts were obtained from suggestions and comments in the assessment questionnaire via google form that had been given to the speaker. Qualitative data of material experts can be seen in table 6.

Table 3.

Qualitative Data of Media Validation Results

| Validator | Suggestions and Comments |
|---|---|
| **1** | Give a clear / best example using the E-Learning developed. |
| **2** | Broadly speaking, the appearance of E-Learning is good, equipped with interesting pictures and videos. |
| **3** | The overall appearance of E-Learning is good and attractive with moving images. |

The readability test was carried out online through the help of google form because when the readability test data was collected, students were learning from home due to the COVID-19 outbreak. Based on the data, there were 30 students who had filled in from 7 different schools (SMAN 1 Genteng, SMAN 1 Malang, SMAN 2 Malang, SMAN 1 Tumpang, MAN 2 Malang, SMAN 1 Jakenan, and MA Al Ittihad), obtained quantitative data and qualitative. Quantitative data were obtained from the form of assessment of teaching materials from various aspects with a five-level

Likert scale. Meanwhile, qualitative data were obtained from the comments and suggestions column from. The quantitative data of the readability test results by students can be seen in table 7.

Table 4.

Results of the Recapitulation of Quantitative Data Readability Test by Students students.

| Percentage of Readability Validation by Students | Criteria |
|---|---|
| 81.6% | Very Worth it |

The result of the readability test of teaching materials by students was 81.6%, indicating that E-Learning teaching materials were enriched with 3D visualization based on Molview, the inquiry model of the topic of intermolecular forces was declared very feasible because the resulting percentage was greater than 80% (Ridwan, 2010). So, this E-learning is suitable for learning about intermolecular force.

Table 5.

Qualitative Data of Readability Test Results by Students

| Students to | Suggestions and Comments |
|---|---|
| 10 | • I really like animated pictures and other interesting pictures, because they can spark enthusiasm for learning and keep me away from getting bored.<br>• The concept map that is presented is very clear so that I can immediately capture the picture of the whole material.<br>• The video explanation also makes very easy for me to study the material.<br>• Moreover, after doing the "question exercises, my understanding is getting better."<br>• The use of the term "interesting / unique like Hen FON makes it easier for me to remember. Maybe it could be reproduced. |
| 16 | Suitable for independent study during the COVID-19 outbreak |
| 24 | Attractive appearance and complete features for independent study |
| 29 | Good for deepening the material but even better if the questions and discussions are added and detailed again |

The following is an example of a display of the E-Learning teaching materials that have been made (Figure 1):

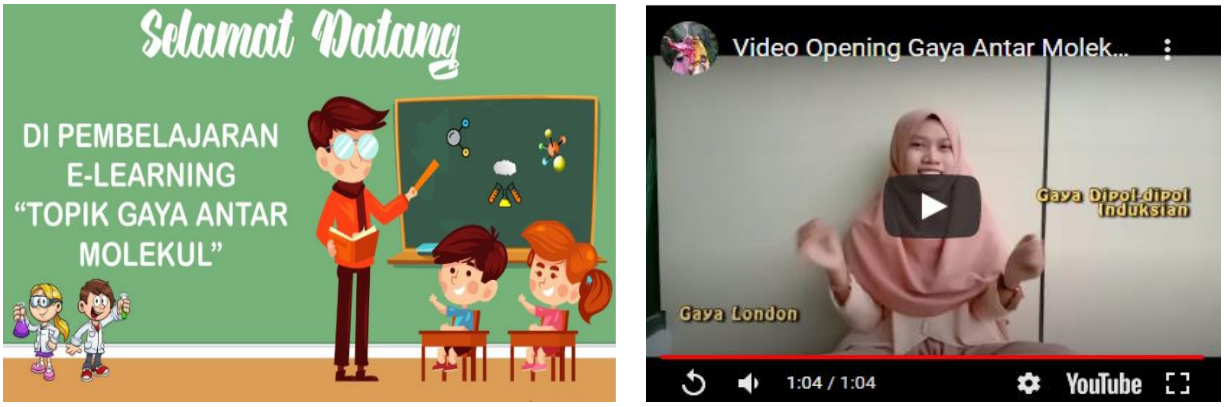


Figure 1. Example of display of E-Learning teaching materials that have been made

## IV. Conclusion

First, chemistry teaching materials that have been applied so far are still dominated by textbooks and the monotonous way of teaching chemistry, teachers makes chemistry often difficult, especially at the microscopic level. One chemical subject that contains quite a lot of microscopic levels is the intermolecular forces. E-Learning as a technology-based teaching material solution that is equipped with molview and is compiled based on a guided inquiry syntax, making it easier for students to deepen the material asynchronous intermolecular forces, especially during the COVID-19 pandemic.

Second, the results of the material expert validation were 85.58% and the media expert validation results were 83.34% and the readability test results conducted by 30 students got a percentage of 81.60%. The three results of the percentage validation show that the E-Learning teaching materials that have been developed are very feasible both in terms of material, media, and readability for students to apply.

## References

[1] Amarlita D, M., Sarfan E. 2014. Analysis of Macroscopic, Microscopic and Symbolic Abilities in Chemical Equilibrium Material. Bimafika Ambon. 6 (1), 677-680.

[2] Hanson, David M. 2007. Design Process-Oriented Guided-Inquiry Activities. New York: Stony Brook University Department of Chemistry.

[3] Inesa Wijaya. 2015. Development of Learning Media for Autoplay Media Studio in Audio System Engineering Subject at SMK Negeri 3 Surabaya. Journal of Electrical Engineering Education. 4 (3).

[4] Lee.WW & Owen. DL 2004. Multimedia-Based Instructional Design, (2nd Ed). San Francisco: Pfeiffer.

[5] Mustaqim, I. 2016. Utilization of Augmented Reality as a Learning Media. Journal of Technology and Vocational Education, 13 (2), 174-183.

[6] Ridwan, MBA2010. Measurement Scale of Research Variables. Alfabeta, Bandung.

[7] Rompayom, Patcharee., Chinda Tambunchong, and Somsong Wongyounoi. 2011. Using Open-Ended Questions to Diagnose Students' Understanding of Inter- and Intramolecular Forces. US-China Education Review. 1 (1), 12-23.

[8] Sadjati, IM 2012. Development of Teaching Materials. In: The Essence of Teaching Materials. Jakarta: Open University.

[9] Sari K., Saputro S., Hastuti B., 2014. Development of Role Playing Game (Rpg) Based Chemistry Educational Games on Atomic Structure Material as Independent Learning Media for Class X Senior High School Students in Purworejo Regency. Journal of Chemical Education (JPK), 3 (2), 96-104.

[10] Stojanovskal, M., Petrusevskil, V, M., Soptrajanov, B. 2014. Study Of The Use Of The Three Levels Of Thinking And Representation. Sec. Nat. Math. Biotech. Sci., MASA, 35 (1), 37–46.

[11] Thadison, Felicia C. 2011. Investigating Macroscopic, Submicroscopic, And Symbolic Connections In A College-Level General Chemistry Laboratory. The University of Southern Mississippi The Aquila Digital Community, 2 (1), 2-14.

[12] Utari, D., Fadiawati, N., Tania, L. 2017. Students' Representation Ability on Chemical Equilibrium Material Using Animations Based on Chemical Representations. Journal of Chemistry Education and Learning, 6 (3).