The making of interactive multimedia orienting toward the three levels of representation in alcohol reaction

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Abstract. Alcohol reaction is one of the concepts in organic chemistry, which has macroscopic, submicroscopic, and symbolic characteristics. Alcohol reaction is usually displayed in macroscopic and symbolic representation only, while in fact should be displayed in submicroscopic representation as well. This ‘research and development’ research aims at creating interactive multimedia that can display the three levels of representation on alcohol reaction and determine its feasibility level. The research results show that the product can display the three levels of representation in alcohol reaction. The macroscopic representation is presented with experimental video of alcohol reaction. The submicroscopic representation is presented with the animation of alcohol reaction mechanism. The symbolic representation is presented with the equation of alcohol reaction. Furthermore, the validation is done through the consideration of 4 experts and the feasibility test involving 15 college students. The result of the validation and feasibility test concludes that interactive multimedia is valid and feasible to be used in learning chemistry.

1. Introduction

Based on its characteristics, chemistry material is categorized into three levels of representation, namely macroscopic, submicroscopic, and symbolic. Moreover, to understand chemistry requires the ability to think using these three levels of representation. Macroscopic representation is a concrete level describing real observations of chemical phenomena occurring. Submicroscopic representation is an abstract level describing a chemical process involving the interaction of atoms, molecules, and ions [8]. Meanwhile, symbolic representation is a chemical language in the form of symbols representing the nature and behavior of chemical substances and chemical processes used to provide explanations at the molecular level [18].

Students have difficulties in solving chemical problems due to lack of ability to connect the three levels of representation [3]. The key to solving chemical problems is the ability to represent chemical phenomena at the submicroscopic level [19]. The inability to represent submicroscopic aspects can inhibit the ability to solve problems related to macroscopic phenomena and symbolic representations [9].

One of the materials learned in chemistry is organic chemistry. The material of organic chemistry is abstract, macroscopic, submicroscopic, and symbolic [11]. One of the concepts in organic chemistry is alcohol and one of its discussions is alcohol reaction. Alcohol reaction is usually displayed in macroscopic and symbolic representations only, i.e. respectively the reaction process and the reaction
equation while it is actually required to display in submicroscopic representation to describe the reaction mechanism. Therefore, we require a teaching material capable of visualizing the three levels of representation in alcohol reactions. In this case, the use of multimedia can do it through animations capable of visualizing phenomena submicroscopically and videos macroscopically [4].

One of teaching materials that allow animation is multimedia. Multimedia-based teaching materials simultaneously combine various media such as audio, video, graphics, text, animation and so on [13]. Then, multimedia recommended to be used in learning is interactive multimedia. Interactive multimedia has a system able to ask something to the users and then take action according to their responses [7].

One of researches conducted in relation to the use multimedia in chemistry learning is a research by Aziz, et al [2] using Interactive Multimedia Chemistry Module (IMCM) in chemistry organic discussing the material of stereochemistry and SN1 and SN2 reaction mechanisms. The multimedia used in this research is designed to visualize the concept of organic chemistry that is abstract and requires high imagination. The results show that the use of multimedia modules is very helpful in improving students' understanding of the teaching and learning of organic chemistry as evidenced by their increased learning outcomes. In addition, previous research has also been conducted by Indriyani (2017) aiming at making multiple representation-based electronic modules on the concept of alcohol. However, it does not really explore alcohol reactions. Therefore, this research makes interactive multimedia orienting toward the three levels of representation in alcohol reactions.

2. Research Method
The research method used here is Research and Development method with ADDIE (analysis, design, development, implementation, and evaluation) model. The product produced is in the form of interactive multimedia orienting to the three levels of representation in alcohol reaction. This interactive multimedia is tested randomly to fifteen students.

3. Results and Discussion
This research procedure follows ADDIE (analysis, design, development, implementation, and evaluation) model. The analysis stage consists of the analysis of concept and multiple representation of alcohol reaction. Based on the results of the concept analysis, a concept map is made by identifying relations between the sub-concepts and then connecting them so that the relations between them can be seen. It is done to make the concept learning easier [23]. Furthermore, the design stage consists of the making of a flowchart and storyboard which will later be used as a reference in making interactive multimedia. The development stage consists of the making of interactive multimedia. This interactive multimedia is made using Adobe Flash Professional CS 6 Action Script 3. The final interactive multimedia product is created in the form of .swf and .exe to run on computer devices. The initial interactive multimedia product is validated by 4 experts consisting of 2 material experts and 2 media experts. The Validation result revised interactive multimedia products. The validation is carried out on three aspects, namely aspects of content / material content, learning, and display.

The validation results from the content aspect can be seen in Table 1. From the table, we can see that interactive multimedia has the average value of $r_{hitung}$ of 0.90. The value indicates that interactive multimedia is valid with high interpretation. It is in accordance with the statement of Sugiyono [15] that teaching material is claimed valid if it has $r_{hitung}$ above $r_{kritis}$ which is 0.30 and according to Arikunto [1], teaching materials with $r_{hitung}$ in a range of $0.80 \leq r \leq 1.00$ have high interpretation. Thus, it can be concluded that form the content aspect, interactive multimedia oriented toward the three levels of representation in alcohol reaction is valid and feasible to be tested.

| No | Statement | Score | Conclusion |
|----|-----------|-------|------------|
| 1  | The suitability of material for learning | V1: 4, V2: 5 | $r_{hitung}$: 0.90, $r_{kritis}$: 0.30 | Valid |

Table 1. The validation results from the content aspect of the interactive multimedia material
objectives

2. The opportunity provided for students to learn independently

3. The interaction between students and interactive multimedia developed

The average validation result from the aspect of content / material content

The validation results from the learning aspect can be seen in Table 2a and 2b. From the learning aspect, interactive multimedia has the average value of $r_{hitung}$ of 0.81 indicating it is feasible to use with high interpretation. However, from the quality points of feedback on evaluation and learning quizzes, the value of $r_{hitung}$ is 0.60, far enough compared with the average $r_{hitung}$ value. Although it is still considered valid but the interpretation is included in a rather low category. This is because the validator assesses there is still a lack of feedback on the quiz contained in interactive multimedia.

**Table 2a.** The validation results from the learning aspect of the interactive multimedia

| No | Statement                                                                 | Score | $r_{hitung}$ | $r_{kritis}$ | Conclusion |
|----|---------------------------------------------------------------------------|-------|--------------|--------------|------------|
| 1  | The suitability of the title of interactive multimedia for alcohol reaction material | 4 5   | 0,90         | 0,30         | Valid      |
| 2  | The accuracy of the presentation order of alcohol reaction material        | 4 5  | 0,90         | 0,30         | Valid      |
| 3  | The comprehensiveness of alcohol reaction material                         | 4 4  | 0,80         | 0,30         | Valid      |
| 4  | The display of the material presentation                                  | 4 5  | 0,90         | 0,30         | Valid      |
| 5  | The material is equipped with examples                                     | 4 4  | 0,80         | 0,30         | Valid      |
| 6  | The ease of learning alcohol reaction material                             | 4 4  | 0,80         | 0,30         | Valid      |
| 7  | The suitability of Bahasa Indonesia easily understood and following the Spell-Enhanced Spelling Guidance (EYD) | 4 4  | 0,80         | 0,30         | Valid      |
| 8  | The connection between alcohol synthesis material presented at the macroscopic, submicroscopic and symbolic level | 4 4  | 0,80         | 0,30         | Valid      |

**Table 2b.** The validation results from the learning aspect of the interactive multimedia

| No | Statement                                                                 | Score | $r_{hitung}$ | $r_{kritis}$ | Conclusion |
|----|---------------------------------------------------------------------------|-------|--------------|--------------|------------|
| 9  | The connection between alcohol reaction material presented at submicroscopic and symbolic level | 4 4   | 0,80         | 0,30         | Valid      |
| 10 | The suitability of the alcohol reaction animation presented at submicroscopic level | 4 4   | 0,80         | 0,30         | Valid      |
| 11 | The suitability of presented at macroscopic                               | 4 4   | 0,80         | 0,30         | Valid      |
Table 2b. The validation results from the learning aspect of the interactive multimedia

| No | Statement                                                                 | Score V1 | r hitung | r kritis | Conclusion |
|----|---------------------------------------------------------------------------|---------|---------|---------|------------|
| 12 | The suitability of interactive multimedia of alcohol reaction orienting toward three levels of representation in chemistry | 4       | 0.80    | 0.30    | Valid      |
| 13 | The suitability of the evaluation questions for learning objectives       | 3       | 0.80    | 0.30    | Valid      |
| 14 | The quality of feedback on learning evaluation and quizzes               | 4       | 0.60    | 0.30    | Valid      |
|    | The average validation result from the learning aspect                    |         | 0.81    | 0.30    | Valid      |

Feedback is information provided by the teacher for students. This information contains corrections to student answers accompanied by the correct answers so that students do not make the same mistakes [21]. It is important to give a feedback to students. It is in accordance with Davies’ opinion in Dimyati and Mudjiono [5] that students will learn more if there is reinforcement given in each step of learning.

Table 3a. The validation results from the display aspect of the interactive multimedia

| No | Statement                                                                 | Score V1 | r hitung | r kritis | Conclusion |
|----|---------------------------------------------------------------------------|---------|---------|---------|------------|
| 1  | The ease of using interactive multimedia (interactive multimedia can be used independently). | 4       | 0.80    | 0.30    | Valid      |
| 2  | The clarity of instructions on how to use the interactive multimedia      | 5       | 0.90    | 0.30    | Valid      |
| 3  | The suitability of the background for the material                        | 5       | 0.80    | 0.30    | Valid      |
| 4  | The suitability of the color proportions for the layout                   | 5       | 0.80    | 0.30    | Valid      |
| 5  | The carrying capacity of the graphics and the quality of the graphics display | 5      | 0.80  | 0.30    | Valid      |
| 6  | The position of layout elements (title, subtitle, text and image)         | 3       | 0.60    | 0.30    | Valid      |
| 7  | The design of interactive multimedia is simple and alluring               | 4       | 0.80    | 0.30    | Valid      |

Table 3b. The validation results from the display aspect of the interactive multimedia

| No | Statement                                                                 | Score V1 | r hitung | r kritis | Conclusion |
|----|---------------------------------------------------------------------------|---------|---------|---------|------------|
| 8  | Using bahasa Indonesia accordingly                                        | 5       | 0.90    | 0.30    | Valid      |
| 9  | Using appropriate font type, size, and color for the ease of reading      | 4       | 0.80    | 0.30    | Valid      |
Table 3a. The validation results from the display aspect of the interactive multimedia

| No | Statement                                                                 | Score | \( r_{hitung} \) | \( r_{kritis} \) | Conclusion |
|----|---------------------------------------------------------------------------|-------|------------------|------------------|------------|
| 10 | The attractiveness of the animation                                       | 4     | 4                | 0.80             | 0.30       | Valid      |
| 11 | The clarity of the animation display presented is in accordance with the material learned. | 5     | 4                | 0.90             | 0.30       | Valid      |
| 12 | The clarity of the modeling or animation on alcohol reaction mechanisms   | 5     | 4                | 0.90             | 0.30       | Valid      |
| 13 | The clarity of the video display presented is in accordance with the material learned. | 5     | 3                | 0.80             | 0.30       | Valid      |
| 14 | Video resolution                                                          | 5     | 4                | 0.90             | 0.30       | Valid      |
| 15 | Using clear navigation button                                              | 4     | 3                | 0.70             | 0.30       | Valid      |
| 16 | The consistency of the button used                                         | 5     | 4                | 0.90             | 0.30       | Valid      |
| 17 | The accuracy of the navigation performance                                 | 5     | 3                | 0.80             | 0.30       | Valid      |
|    | The average validation result from the display aspect                      |       | 0.82             | 0.30             | Valid      |

The implementation stage consists of a feasibility test of revised interactive multimedia given to 15 students who had taken organic chemistry I. The feasibility test is carried out using a questionnaire referring to Windiyani [22]. The questionnaire contains several criteria, namely students’ acceptance, benefits, conditions of students’ interest and motivation, and display. Based on Table 4, overall, interactive multimedia is included in the feasible category with the average percentage of 90.22%. According to Sudjana [14], teaching material with a percentage of 90 - 100% feasibility is declared feasible.

The validation results from the display aspect can be seen in Table 3a and 3b. From the display aspect, interactive multimedia has the average value of \( r_{hitung} \) of 0.82 indicating it is feasible to use with high interpretation. There is a comment from the validator regarding the display for the point of simple and alluring multimedia design. At this point, it has \( r_{hitung} \) of 0.80 with high interpretation, the validator considers the display of this multimedia quite simple but still less attractive. This is in line with the statement of Diseko in Sumarno [16] that argues that the principle of learning multimedia design is simplicity, so that students can understand the concept easier. In addition, there are also some points with \( r_{hitung} \) far different from the average. The point of the layout element position (title, subtitle, text and image) gets \( r_{hitung} \) of 0.60. Although it is still considered valid but the interpretation is included in a rather low category. In relation to this, there are some suggestions from the validator to fix the text size to be larger and move the animation to a new scene. In addition, the point of using clear navigation button gets \( r_{hitung} \) of 0.70. Even though it is still considered valid but the interpretation is only categorized as high enough. This is because the color of the navigation button does not contrast with the background so it is considered less clear. For the improvement, the validator suggests to change the color to white.

Table 4. The feasibility test results of the interactive multimedia

| No | Assessment criteria        | YES | NO |
|----|----------------------------|-----|----|
| 1  | Students’ Acceptance       |     |    |
Table 4. The feasibility test results of the interactive multimedia

| No | Assessment criteria | YES | NO |
|----|---------------------|-----|----|
|    |                     | F   | %  | F  | %  |
| a) | There is a relation between alcohol reaction material and life phenomena | 8   | 53.33 | 7  | 46.67 |
| 2  | Benefits            |     |     |    |    |
| b) | Easing the learning process of understanding alcohol reaction | 15  | 100 | 0  | 0  |
| c) | Easing the learning process of understanding macroscopic, submicroscopic, and symbolic aspects of alcohol reaction | 15  | 100 | 0  | 0  |
| d) | Easing the learning process of connecting the three levels of representation in chemistry on alcohol reaction material | 15  | 100 | 0  | 0  |
| 3  | The Condition of Students’ Interest and Motivation |     |     |    |    |
| e) | Fostering students’ interest in learning alcohol reaction | 15  | 100 | 0  | 0  |
| f) | Growing students’ motivation in learning alcohol reaction | 15  | 100 | 0  | 0  |
| 4  | Display             |     |     |    |    |
| g) | The text is readable | 13  | 86.67 | 2  | 13.33 |
| h) | The layout (layout of text and images) is proportional | 13  | 86.67 | 2  | 13.33 |
| i) | The background is suitable | 13  | 86.67 | 2  | 13.33 |
| j) | The media is attractive | 12  | 80  | 3  | 20  |
| 5  | Material Content    |     |     |    |    |
| a) | The suitability of images, animations, and video presented for the concept of alcohol reaction | 15  | 100 | 0  | 0  |
| b) | The clarity of the concept of alcohol reaction presented | 15  | 100 | 0  | 0  |
| c) | The accuracy of the language used | 12  | 80  | 3  | 20  |
| d) | The ease of understanding the concept of alcohol reaction | 12  | 80  | 3  | 20  |
|    | The average result   | 90.22 |     | 9.78 |     |

Criteria of benefits consist of several categories, namely easing the learning process of understanding alcohol reaction, easing the learning process of understanding macroscopic, submicroscopic, and symbolic aspects of alcohol reaction, and easing the learning process of connecting the three levels of representation in chemistry on alcohol reaction material. All respondents answered yes to these aspects. This is in accordance with Smaldino et al. [13] stating that animation programs in multimedia can be used to show dynamic process simulations of both concrete and abstract objects. The use of images, animation, and videos can help students to understand chemistry material since with the use of various multimedia, the representations at the macroscopic, submicroscopic and symbolic levels can be displayed optimally.

Criteria of the condition of students’ interest consist of several categories, namely fostering students’ interest and curiosity in learning alcohol reaction and growing students’ motivation in learning the concept of alcohol. All respondents answered yes to these aspects. This is in accordance with the statement of Munadi [12] that multimedia can increase learning motivation, and Wahyudin, et al. [20] that learning with multimedia can increase interest and understanding.

Criteria of the material content consist of several categories, namely the suitability of images, animations, and video presented for the concept of alcohol reaction, and the clarity of the concept of alcohol reaction presented with a score of 100% each. It means that all respondents answered yes. This is in accordance with the statement of Diseko in Sumarno [16] that the principle of learning multimedia design is simplicity, so that students can understand the concept easier. Meanwhile, the
categories of the accuracy of the language used and the ease of understanding the concept of alcohol reaction get a score of 80% each. It shows that there are still some respondents who still do not feel easy to understand the concept of alcohol reactions. This is because the concept of alcohol reactions is included in abstract concept that is hard to understand [17].

Criteria of the display consists of categories including readable text, proportional layout, and suitable background which all get a score of 86,67% each, and attractive media which gets a score of 80%. It shows that there are some respondents answering No. Basically, the display has been made simple, as stated by Diseko in Sumarno [16] that the principle of learning multimedia design is simplicity, but because filling out the questionnaire is subjective, it allows respondents to answer no.

Furthermore, criteria of students’ acceptance get the lowest score of all with 53,33% answering YES and the rest answering NO. These criteria consist of only one category There is a relation between alcohol reaction material and life phenomena. The score obtained indicates that interactive multimedia does not really show the relation between alcohol reaction material and life phenomena. It means that interactive multimedia must also support to improve scientific literacy skills. As stated by Mulyani in Kusumawadhani, et al. [10] that scientific literacy is important to master because of its relation to how students can understand the environment, health, economy, and other problems faced by modern society highly dependent on technology, progress and development of science. Scientific literacy is usually applied to learning with discovery learning models as Irmita and Atun [6] did by developing learning with TPACK (Technological Pedagogical and Content Knowledge) approach. Learning developed to improve scientific literacy includes three aspects, namely the aspect of scientific context in daily life, scientific content in the form of chemistry material, and scientific process in the form of identifying scientific issues. The learning of scientific literacy can also be developed using multimedia as Kusumawadhani, et al. [10] did by developing interactive multimedia to foster scientific literacy in the concept of periodic table.

Even though the results of the validation and limited testing state that interactive multimedia is feasible, the reaction of alcohol is feasible, the relation alcohol reaction material and life phenomena must be a further development to fix the existing deficiencies as well as a further research to examine its effectiveness in the learning process.

The improvement of interactive multimedia is carried out at the evaluation stage. This stage is the improvement of interactive multimedia products after seeing the responses of respondents in the feasibility test. The final result of this stage is the final product of interactive multimedia.

4. Conclusion
The product of interactive multimedia obtains interactivity through directing questions allowing users to analyze phenomena regarding alcohol synthesis and reaction with macroscopic, submicroscopic, and symbolic visualization. The final product of interactive multimedia is obtained after passing through the stages of analysis, design, development, implementation and evaluation. The results of the feasibility test based on the responses of fifteen students toward interactive multimedia orienting toward the three levels of representation in alcohol reactions show that the average espone of agreement is 90.22% and disagreement is 9.78%. Based on these results, interactive multimedia is feasible to be used.

References
[1] Arikunto. (2013). Prosedur Penelitian: Suatu Pendekatan Praktik. Jakarta: PT Rineka Cipta.
[2] Azziz, S. S. A., Suhairun, A. A., Siais, S., Talib, O., Zain, N. Z. M., Shariman, T. P. N. T., … Jusoff, K. (2013). Keberkesanan Modul Multimedia Kimia Organik: Mekanisme Tindak Balas SN1 dan SN2. Asia Pasific Journal Of Educators and Education, 28, 53–68.
[3] Chittleborough, G., & Treagust, D. F. (2007). The Modelling Ability of Non Major Chemistry Students and Their Understanding of The Submicroscopic level. Chemistry Education Research and Practice, 8(3), 274–292.
[4] Chiu, M.-H., & Wu, H. (2009). The Roles of Multimedia in the Teaching and Learning of the
Triplet Relationship in Chemistry. In Multiple Representations in Chemical Education, Models and Modeling in Science Education 4 251–283.

[5] Dimyati, & Mudjiono. (2002). Belajar dan pembelajaran. Jakarta: PT Rineka Cipta.

[6] Irmita, L. U., & Atun, S. (2017). Pengembangan Perangkat Pembelajaran Menggunakan Pendekatan TPACK Untuk Meningkatkan Literasi Sains. Jurnal Tadris Kimia, 2(1), 84–90.

[7] Jauhari, J. (2009). Studi Terhadap Penggunaan Multimedia Interaktif Dalam. In Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA (hal. 425–432).

[8] Johnstone, A. H. (2006). Chemical education research in Glasgow in perspective. Chemistry Education Research and Practice, 7(2), 49–63.

[9] Kozma, R., & Russell, J. (2005). Students Becoming Chemists: Developing Representational Competence. In Visualization in Science Education (hal. 121–145).

[10] Kusumawadhani, R., Suryati, & Khery, Y. (2017). Pengembangan Media Pembelajaran Kimia Berbasis Android Untuk Penumbuhan Literasi Sains Siswa Pada Materi Sistem Periodik Unsur. Jurnal Ilmian pendidikan Kimia “Hydrogen,” 5(2), 60–67.

[11] Mahaffy, P. (2004). The Future Shape Chemistry Education Introduction: Shapes in Chemistry and Chemistry Education. Chemistry Education: Research and Practice, 5(3), 229–245.

[12] Munadi. (2012). Media Pembelajaran: Sebuah pendekatan baru. Jakarta: Gaung Persada Pers.

[13] Smaldino, S., Russel, J., Heinich, R., & Molenda, M. (2005). Instructional Technology and Media for Learning. New Jersey: Pearson Education, Inc.

[14] Sudjana. (2005). Metode Statistika. Bandung: Tarsito.

[15] Sugiyono. (2015). Metode Penelitian Pendidikan (Pendekatan Kuantitatif, Kualitatif dan R&D). Bandung: Alfabeta.

[16] Sumarno, A. (2011). Prinsip-Prinsip Desain Multimedia Pembelajaran.

[17] Sunyono, I. W., Susanto, E., & Suyadi, G. (2009). Kesulitan Dalam Pembelajaran Kimia SMA Kelas X di Profinsi Lampung. Jurnal Pendidikan MIPA, 10(2), 9–18.

[18] Talanquer, V. (2011). Macro, Submicro, and Symbolic: The many faces of the chemistry “triplet.” International Journal of Science Education, 33(2), 179–195.

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

[20] Wahyudin, Sutikno, & Isa, A. (2010). Keefektifan Pembelajaran Berbantuan Multimedia Menggunakan Metode Inkuiri Terbimbing Untuk Meningkatkan Minat Dan Pemahaman Siswa. Jurnal Pendidikan Fisika Indonesia (Indonesian Journal of Physics Education), 6(1), 58–62.

[21] Wijayanti, I., Kusumawati, I., & Kushandayani, T. (2008). Penggunaan Model Pembelajaran Numbered Heads Together untuk Meningkatkan Hasil Belajar Kimia. Inovasi Pendidikan Kimia, 2(2), 281–286.

[22] Windiyani, T. (2012). Instrumen Untuk Menjaring Data Interval , Nominal , Ordinal Dan Data Tentang Kondisi , Keadaan , Hal Tertentu Dan Data. jurnal pendidikan dasar, 3(5), 203–207.

[23] Yunita. (2012). Panduan Pengelolaan Laboratorium Kimia. Bandung: CV. Insan mandiri.