Making Interactive Learning Media Based on Augmented Reality on the Concept of Molecular Chirality

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Abstract. This research is motivated by the difficulty of students in representing submicroscopic concepts in the material of molecular chirality. Therefore, learning media are needed that can establish two-way communication in visualizing molecular chirality to be easily understood by students. The method used is design-based research (DBR) with a modified ADDIE model. The stages of the research include analysis of the concept of molecular chirality, design, and media creation. Based on the results of research and development, the conclusions are AR-based media on the concept of molecular chirality has contrasting coloring characteristics, interactive, and 3D object visualization so that students can develop student responses actively and student submicroscopic representation, based on validation tests on aspects of visual communication, software engineering, linguistic feasibility, cognitive learning, the substance of the concept of molecular chirality, and the feasibility of their use according to the purpose of making the product, obtained an average $r_{calculation}$ of 0.8807 or feasible, while the average value of the feasibility of limited trials was obtained 90.12%. This shows that the presentation of interactive learning media based on AR on the concept of molecular chirality is suitable to be used as a supporting medium in learning.

1. Introduction
Chemistry is considered that is difficult for students because some of the concepts are abstract, there is not all concept that can be used in learning activities [1]. Chemical concepts that are abstract and require good visualization is the concept of molecular chirality. Molecular chirality is a suitable topic to study because it requires students to be able to visualize three-dimensional molecular structures [2], but chirality understood by students is often wrong in the two-dimensional geometry structure that contained in teaching materials [3]. The tools commonly used in learning are real models[3], but this model still makes students become passive, therefore more developed technology is needed so that the learning process becomes interactive [4-5]. One of the fastest growing interaction technologies is augmented reality (AR) technology [4,6]. AR allows users to interact with virtual objects inserted in real objects around them [7]. AR applications on smartphone devices give students the freedom to enjoy learning anywhere, anytime and at the same time, AR takes them in three-dimensional learning experience [8] Research that has been done related to the development of AR has a positive impact in learning the concept of metal structures because it can develop the ability of students' submicroscopic representation [9] and on the concept of molecular geometry, AR has the potential to be implemented in chemistry learning [10]. Therefore, researchers initiated the development of interactive learning media based on the
augmented reality of the concept of molecular chirality, so that it can help students visualize molecular chirality through 3D objects.

2. Experimental Method
This study uses the Design-Based Research (DBR) method which consists of two processes namely the design process and the scientific research process that allows researchers to produce useful products and effective ideas to solve problems in the world of education [11-12]. The data source in this study were ten students of UIN Sunan Gunung Djati Chemical Education to test the feasibility of interactive learning media based on AR on the concept of molecular chirality. The display of AR-based interactive learning media was made using a modified ADDIE model into three stages, namely the analysis stage, design stage, and the manufacturing stage [13]. Furthermore, a limited trial was conducted on ten students of UIN Sunan Gunung Djati Bandung Chemical Education students who had filled out the student worksheets and AR chirality molecular questionnaires.

3. Result and Discussion
3.1 Display from the Analysis Phase
The analysis phase that has been carried out produces an analysis view of concepts and concept maps based on the curriculum.

3.2 Display of the Design Development Phase
In the design phase, the scenario of making AR-based learning media is designed on the concept of molecular chirality in the form of flowcharts and storyboards. The storyboard that contains a user interface (UI) is created using Microsoft Word 2010 and a flowchart that contains user experience (UX) using Microsoft Office Visio 2010.

3.3 Display of Media Development Phase
At the manufacturing stage, collecting resources such as images, sounds and objects are needed, then registering marker images that have been designed with Coreldraw X8 to developer Vuforia [14]. After that, the resource is processed in the Unity 3D application[14]. Then processing the layout on the storyboard that has been designed in unity3D [15]. Furthermore, the flowchart is processed with a system developed in Unity3D by coding using MonoDevelop with CS-Script Language [16].

3.3.1 Display Instructions for Student Worksheets
The student worksheet serves to express the results of the exploration of the visualization of molecular chirality using AR and contains guidelines for using media, learning indicators, learning objectives and questions.

3.3.2 Display of the AR media opening page interface
The opening page display contains the intended hyperlinks such as the media usage instructions button, learning objectives, compiler profiles, quiz, as well as the main menu that contains menus to enter 3D object views. The initial view can be seen in Figure 1.
3.3.3 Display usage instructions
This interface aims to provide guides for information on how to use the media. Display instructions for use can be seen in Figure 2.

3.3.4 Display of Learning Objectives
The text of the learning objectives presented aims to provide information about what students must achieve in learning. The display of learning objectives can be seen in Figure 3.

3.3.5 Display of Compiler Profile
The compiler profile interface contains information that compiles AR-based interactive learning media.

3.3.6 Main Page Display (Menu)
The main menu interface contains menus related to molecular chirality content. The main menu display can be seen in Figure 4. The sub-concepts in the main menu can guide users of interactive learning media based on AR on the concept of molecular chirality in running applications to observe three-dimensional submicroscopic visualization of several molecular chirality concepts. An example display of illustration of molecular chirality menu selection (number 2 button).

3.3.7 Display of Molecular Chirality Submenu
Elaboration of molecular chirality is opened systematically and sequentially as the guide presented on student worksheets, the AR system of molecular chirality runs by detecting markers through a smartphone camera. So that the detected marker displays 3D objects according to the commands contained in the scene of each subconcept. The molecular chirality submenu can be seen in Figure 5.

3.3.8 Display of Augmented Reality Markers
Markers are needed because the type of AR used in this media is a type of target image that requires images to create 3D objects. Besides this marker is used when students work on the worksheet that has been made. Display markers of molecular chirality can be seen in Figure 6.
The role of markers as receptors (sensor recipients on AR cameras), in this study only required one marker for all things, while in the worksheet there are questions that meet the sub-indicators, each student must complete the work.

3.3.9 Questions Display on Student Worksheets
the worksheet has nine description questions in accordance with the indicator that has been made. This question is in conjunction with the application of molecular chirality AR, as for one of the questions that direct students to understand the concept of molecular chirality, visualization of 3D object shapes will be presented in Table 1.

Table 1 Visualization of molecular chirality material in AR-based interactive learning media

| Page      | Visualization of 3D Objects |
|-----------|-----------------------------|
| Chiral molecules | ![Visualization of 3D Objects](image1) | ![Visualization of 3D Objects](image2) |
| Achiral molecules | ![Visualization of 3D Objects](image3) | ![Visualization of 3D Objects](image4) |

Question: Then go back to the main menu and press the molecular chirality button, first press the chiral molecule button, observe and understand the information related to the object displayed when it is superimposable or mirrored, then return to the previous menu to move to the next observation, then press the achiral molecule button. Based on the chiral molecules and the achiral molecules that you have observed in the application, what is the difference between chiral and achiral molecules? and what are the characteristics?

3.3.10 Quiz Display
The quiz interface is used to find out how far the user's understanding is related to the content of molecular chirality after using AR-based interactive learning media. Some examples of quiz views can be seen in Figures 7 and 8, while the discussion scenes can be seen in figures 9 and 10.
3.4 Limited Trial Results

The limited trial serves to determine the achievement based on indicators from interactive learning AR media on the concept of molecular chirality. Limited trials were conducted on 10 respondents (students of the Chemical Education Study Program of UIN Sunan Gunung Djati Bandung). In table 2 data grouped based on predetermined indicators.

Table 2 Recapitulation of the results of questionnaires based on indicators

| No. | Indicator                                                                 | Question Number | Score | Maximum Score | Percentage (%) |
|-----|---------------------------------------------------------------------------|-----------------|-------|---------------|----------------|
| 1   | Media relevance with learning objectives.                                 | 1, 6, 13        | 135   | 150           | 90             |
| 2   | The efficiency of using media products is reviewed in terms of time.       | 2, 16           | 87    | 100           | 87             |
| 3   | The effectiveness of the media to overcome the limitations of props.      | 3, 11, 14, 19   | 184   | 200           | 92             |
| 4   | The flexibility of media use.                                             | 7, 8, 12        | 136   | 150           | 90.66          |
| 5   | Media display.                                                            | 4, 9, 18        | 126   | 150           | 84             |
| 6   | Increased student motivation in learning                                  | 5, 6, 20        | 140   | 150           | 93.33          |
| 7   | The ability to encourage students to learn further.                       | 10, 15          | 94    | 100           | 94             |
| 8   | Prospects for the development of other similar media.                     | 17              | 50    | 45            | 90             |

Average value 90.12%

Based on Table 4.6 shows that 6 indicators with a percentage range of 90-94% indicate that AR media is very feasible. While 2 indicators with a range of 84-87% indicate that AR media is feasible. An average score of 90.12% was obtained from limited trials which showed that the use of interactive
learning media based on AR on the concept of molecular chirality can help and support the teaching and learning process in the classroom [14].

4. Conclusion
The appearance of interactive learning media based on AR on the concept of molecular chirality has contrasting coloring characteristics, interactive, and 3D object visualization so that it can develop student responses actively and student submicroscopic representation. The results of the trial are limited with an average value of each indicator of 90.12% indicating interactive learning media based on AR on the concept of molecular chirality is categorized as feasible to be used as learning support media.

References
[1] R. . Marsita, S. Priatmoko, and E. Kusuma 2010 Analisis Kesulitan Belajar Kimia Siswa SMA Dalam Memahami Materi Larutan Penyangga Dengan Menggunakan Two-Tier Multiple Choice Diagnostic Instrument J. Inov. Pendidik. Kim. 4 1 512–520
[2] M. Propova, S. Bretz & C. . Hartley 2016 Visualizing Molecular Chirality in the Organic Chemistry Laboratory Using Cholesteric Liquid Crystals J. Chem. Educ. 93 6 1096–1099
[3] A. Stull, T. Barrett & M. Hegarty 2013 Usability of Concrete and Virtual Models in Chemistry Instruction Comput. Human Behav. 29 6 2546–2556
[4] L. Kamelia 2015 Perkembangan Teknologi Augmented Reality Sebagai Media Pembelajaran Interaktif Pada Mata Kuliah Kimia Dasar Jurnal Pendidikan Kimia 1 512–520
[5] Irwandani, Latifah, S., Asyhari, A., Muzannur, & Widayanti 2017 Modul Digital Interaktif Berbasis Articulate Studio’13: Pengembangan pada Materi Gerak Melingkar Kelas X Jurnal Ilmiah Pendidikan Fisika Al-Biruni 6 2 221–231
[6] Irwandani, Latifah, S, Asyhari, A Muzannur, & Widayanti 2017 Modul Digital Interaktif Berbasis Articulate Studio’13: Pengembangan pada Materi Gerak Melingkar Kelas X Jurnal Ilmiah Pendidikan Fisika Al-Biruni 6 2 221–231
[7] S. Cai, X. Wang & F. Chiang 2014 A Case Study of Augmented Reality Simulation System Application in a Chemistry Course Comput. Hum. Behav. 37 31–40
[8] S. Cai, X. Wang, M. Gao & S. Yu 2012 Simulation Teaching in 3D Augmented Reality Environment IAI International Conference on Advanced Applied Informatics. 83–88
[9] F. Irwansyah, I. Ramdani & I. Farida 2017 The Development of an Augmented Reality (AR) Technology-Based Learning Media in Metal Structure Concept Ideas for 21st Century Education. 233–237
[10] F. Irwansyah, Y. Yusuf, I. Faida & M. Ramdhani 2018 Augmented Reality (AR) Technology on The Android Operating System in Chemistry Learning IOP Conference Series: Materials Science and Engineering
[11] M. . Easterday, D. Rees Lewis, and E. Gerber, “Design-Based Research Process: Problems, Phases, and Applications,” in Proceedings of the International Conference of the Learning Sciences, 2014, pp. 317–324
[12] Diani, R., Yuberti & Syarlisisjawan, M. R 2018 Web-Enhanced Course Based On Problem-Based Learning (PBL): Development Of Interactive Learning Media For Basic Physics II Jurnal Ilmiah Pendidikan Fisika Al-Biruni, 7 1 105–116
[13] N. Aldoobie 2015 ADDIE Model Am. Int. J. Contemp. Res. 5 6 68–72
[14] S. Sannikov, F. Zhdanov, P. Cheobotarev & P. Rabinovich 2015 Interactive Educational Content Based on Augmented Reality and 3D Visualization Procedia Comput. Sci. 66 720–729
[15] M. Bower, C. Howe, N. MyVredie, A. Robinson & D. Grover 2014 Augmented Reality
in Education–Cases, Places, and Potentials *EMI. Educ. Media Int.* 51 1 1–15

[16] M. Johnson & J. Henley 2014 *Learning 2D Game Development with Unity: A Hands-On Guide to Game Creation* (Google Book)