Development of Integrated Blog-Based Teaching Materials of Dyestuffs Adsorption to Improve Students' Literacy in Chemistry

Areski Febriani, Septika A. Umaro, Euis Nursa'adah, and M. Lutfi Firdaus(✉)

Graduate School of Sciene Education, University of Bengkulu, Bengkulu, Indonesia
lutfi@unib.ac.id

Abstract. Chemical literacy is an understanding of the nature of chemical particles, chemical reactions, chemical laws and theories, as well as general chemical applications in everyday life. In Indonesia, students' chemical literacy is still low that need further action to improve it. To boost the students' chemical literacy, an appropriate learning strategy is needed. The presentation of chemical theory with everyday life and current issues in the world of science can be the main attraction for students. The purpose of this research was to develop inquiry-based teaching materials that are made following the development of learning in the 4.0 industrial revolution era by utilizing blogs. This research was a research and development design. The subjects in this study were 30 students of class X of high school in Bengkulu City, Indonesia. The data on students' chemical literacy were obtained from the pre-test and post-test scores. Based on the data analysis conducted, students' chemical literacy increased with an average n-gain of 0.71 that is in the high category. Thus, the proposed chemical blog is suitable to improve the students' literacy that can be developed also for other subjects in the field of chemistry.

Keywords: Blog · chemical literacy · inquiry · dye adsorption · MOFs

1 Introduction

One of the materials in chemistry subjects for high school is chemical bonding material. Chemical bonding is classified as abstract that hard to understand yet must be well understood by students. Chemical bonds have a submicroscopic concept because learning about the formation of bonds of an element is quite difficult for students to understand. One example of chemical bonds is the formation of water molecules which are formed through one type of chemical bond, namely hydrogen bonds. Another type of chemical bond is coordination bond, this coordination bond occurs in the formation of Metal Organic Frameworks (MOFs). MOFs are inorganic compounds composed of clusters of metal ions that form coordination bonds with organic molecules into one, two or three-dimensional structures. MOFs are formed through coordination bonds between metals as central atoms and organic ligands [1]. Metal ions and organic ligands in the formation of MOFs have a very important role, because if the type of metal and ligand is changed, it will form a new sub-class of MOFs [2]. MOFs have several distinctive

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characteristics, such as varied structure, large surface area, and good adsorption ability. The large specific surface area and perfect porous structure cause MOFs to have a higher adsorption capacity when compared to activated carbon, silica, and zeolites [3]. The application of MOFs as an adsorbent of hazardous dyes contained in wastewater can be used as a context to improve mastery of the concept of chemical bonding, especially in the sub-material of intermolecular forces. This is because the adsorption process occurs through the interaction between the adsorbate (dyes) and the adsorbent (MOFs).

Based on preliminary studies conducted on the content of teaching materials used in textbooks, there is still very little content that can explain the microscopic side of chemistry. Most teaching materials only focus on the context of chemical bonding material but are not built from content. So it is necessary to apply a learning model that can build chemistry content so that students can understand concepts independently and learning will be more memorable for students. According to Straits and Wilke, the inquiry learning model is one of the learning models that plays an important role in building a constructivist learning paradigm that emphasizes the active learning of students [4]. In the inquiry learning model, students are trained to carry out scientific processes to find concepts. Students are also trained to solve problems through observation, and relate the material to problems in everyday life. Learning with a highly integrated inquiry approach includes the application of scientific processes with logical thinking processes and critical thinking. Inquiry is an approach to gain knowledge and understand by asking questions, observing, investigating, analyzing, and evaluating [5]. Therefore, inquiry-based learning can be used to teach the concept of MOFs to students. The syntax of the guided inquiry learning model used is orientation, formulating problems, formulating hypotheses, collecting data, testing hypotheses, and formulating conclusions [6]. Learning with a highly integrated inquiry approach includes the application of scientific processes with logical thinking processes and critical thinking. Inquiry is an approach to gain knowledge and understand by asking questions, observing, investigating, analyzing, and evaluating. Therefore, inquiry-based learning can be used to teach the concept of MOFs to students. The syntax of the guided inquiry learning model used is orientation, formulating problems, formulating hypotheses, collecting data, testing hypotheses, and formulating conclusions. Learning with a highly integrated inquiry approach includes the application of scientific processes with logical thinking processes and critical thinking. Inquiry is an approach to gain knowledge and understand by asking questions, observing, investigating, analyzing, and evaluating [5]. Therefore, inquiry-based learning can be used to teach the concept of MOFs to students. The syntax of the guided inquiry learning model used is orientation, formulating problems, formulating hypotheses, collecting data, testing hypotheses, and formulating conclusions and evaluation [5, 6].

The process of students in inquiry-based learning will be presented in the form of a chemistry learning blog. This is because in modern times students are very fixated on the use of smartphones, all student activities can be done with smartphones. Usually the activities they do are playing social media and watching videos that they think are interesting. This student activity made researchers interested in making learning media that can be accessed on students' smartphones. In addition to utilizing technological developments in the 4.0 revolution era in the world of education, this learning media is expected to increase students' understanding of learning materials because media can be

accessed anywhere. This inquiry-based learning can be used as a tool to train students' scientific literacy if the learning tool allows students to find their own knowledge. In the learning process, all activities carried out by students are directed to seek and find their own answers to a question, which is expected to improve science process skills [6].

Chemical literacy is one of the important elements that must be developed in education. Chemical literacy is related to all humans of all ages, all levels of education, both science and non-science. Chemical literacy is an understanding of the nature of matter particles, chemical reactions, chemical laws and theories, and general chemical applications in everyday life. People who have chemical literacy must understand the basic concepts of science or chemistry) [7]. The importance of chemical literacy relates to how students are able to appreciate nature by utilizing the science and technology that they have mastered. Based on the above background, an integrated blog-based teaching material for adsorption of dye waste by MOFs will be developed to improve students' chemical literacy. Through these teaching materials, students are required to be active in the learning process. So that it can improve students' chemical literacy in achieving the desired competence.

2 Research Method

The type of research carried out is Research and Development which implements the results of the MOFs synthesis for dye adsorption. The product developed is a blog-based teaching material. The steps in this study use the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation) which is a model in which it represents the stages in a systematic (organized) and systematic manner in use in order to achieve the desired results.

This research begins with the analysis phase which consists of needs analysis, student analysis and concept analysis. Next is the design stage namely designing a blog-based teaching material that can be used in learning chemistry on chemical bonding material to improve students' chemical literacy. The feasibility of the product is assessed at the development stage by means of validation, after being declared feasible; the implementation is carried out face-to-face to high school students of class X on chemical bonding material. The final revision of the product is carried out at the evaluation stage.

3 Results and Discussion

3.1 Analysis Results

Based on the results of the analysis, it is known that learning chemistry generally uses textbooks obtained from the government. The implementation of chemistry learning tends to be teacher-centered; the material delivered by the teacher is also fixed on the textbook obtained. For chemical bonding material, it explains the concept of chemical bonds and examples of compounds from these chemical bonds. The content of chemical bonding material is only introduced conceptually and has not been linked to the context of the problems that exist in the student environment. Even though there are a lot of potential problems in the environment around students that can be developed to be used

Fig. 1. The blog domain website that can be access freely through the internet.

as contexts for the learning content of chemical bonding material. One of these problems is environmental pollution caused by textile industry dye waste in Bengkulu City.

Student activities that cannot be separated from the use of smartphones can be utilized in the development of technology-based teaching materials. By utilizing the learning model, a teaching material can be developed that requires students to be active in the learning process. This will make learning more memorable for students and improve students' conceptual understanding of the subject matter.

3.2 Design Results

The development of a chemical bonding material learning blog that applies the adsorption context begins with compiling chemical bonding material that will be displayed in the learning blog. The content of the material includes chemical bonding material starting from ionic bonds, metallic bonds, and covalent bonds. Each contents of chemical bond is discussed from the concept, structure to the properties that arise based on its structure. The blog display design was chosen according to the subject of chemical bonding and dye adsorption. This display contains the title of the blog, illustration images of dyes and chemical bonds, as well as a search column. In the main view there is also a menu on the blog that can be clicked directly (Fig. 1).

3.3 Development Results

The validation of this learning blog is carried out by expert validators by asking for theoretical and practical considerations regarding product content from a technical and

Table 1. Results of Data Analysis Validation of Learning Blog Materials

Inquiry Stage	Validator					CVR	Description
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5		
Orientation	1	1	1	1	1	1	Valid
Formulation of the problem	1	1	1	1	1	1	Valid
Hypothesis Formulation	1	1	1	1	1	1	Valid
Data collection	1	1	1	1	1	1	Valid
Hypothesis test	1	1	1	1	1	1	Valid
Conclusion Drawing	1	1	1	1	1	1	Valid
Average						1	Valid

teaching point of view. Criticisms and suggestions from validators are used as reference materials in the development of this learning blog. Expert validators consist of media expert validators and material experts. Each validator consists of 5 people who are competent in their field. This validation process is carried out with several revisions to obtain a final score for the product. The scores obtained for blog-based teaching materials in the form of a scoring rubric were analyzed using the Aiken test validity analysis. The results of the analysis can be categorized as valid if they meet the Aiken coefficient limit. The Aiken coefficient limit requirement for 5 validators is 0.99.

Based on Table 1, it can be seen that the results of the validity of the inquiry-based Metal Organic Frameworks learning blog material obtained an average Content Validity Ratio (CVR) value of 1 which was declared feasible as a teaching material that implemented the results of adsorption of dye waste as the implementation of chemical materials. The minimum value for CVR with 5 experts to get a decent category is 0.99 [8]. Thus, it can be concluded that the developed teaching materials are feasible to be published and used at the implementation stage to measure students' chemical literacy.

In addition to material validation, the media blog was also tested for validation. The blog design results were validated by 5 validators who are experts in their fields. The validation results can be seen in the Table 2.

Table 2 shows that the results of the validity of the learning blog media aspect also obtained an average CVR value of 1. It can be assumed that the blog that was developed is feasible to be used as a medium to teach chemical bonding material. The use of media in learning can make it easier for students to understand something abstract to be more concrete. This is in accordance with the opinion of Jerome S. Bruner that students learn through three stages, namely enactive, iconic, and symbolic [9].

Table 2. Results of Blog Media Validation Data Analysis

Aspect	Validator					CVR	Description
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5		
Usability	1	1	1	1	1	1	Valid
Functionality	1	1	1	1	1	1	Valid
Visual Communication	1	1	1	1	1	1	Valid
Average						1	Valid

Table 3. Achievement of Students' Chemical Literacy

Literacy Domain	Specific Components	Pre-test	Post-test	n-gain	Description
Content	Chemical Bond	41.67	81.33	0.70	Average
Context	MOFs as adsorbent	38.67	81.33	0.68	Average
Attitude	Response to the environment	50	87.67	0.75	High
Chemical Literacy Average		43.45	83.44	0.71	High

3.4 Implementation Results

The implementation of learning is carried out in accordance with the learning implementation plan that has been prepared. The learning was carried out in class X students as many as 30 students. Learning is done by group discussion about the application of metal organic frameworks as the implementation of chemical bonding material. Group discussions were carried out according to the inquiry learning steps that were guided directly by the researcher until the material was completely understood by the students.

After completing the learning, students are given a posttest with literacy questions as many as 10 questions. The effectiveness of learning blogs on learning is seen as its impact on increasing students' chemical literacy. To see the increase in chemical literacy, analysis was carried out by calculating the n-gain. In this section, the effectiveness of learning blogs on students' chemical literacy results will be described. The overall achievement of chemical literacy of students can be seen in the Table 3.

Table 3 shows that in general there is an increase in chemical literacy with an average n-gain value of 0.71 (high). The response to the environment of students got the highest n-gain (0.75), while the n-gain MOFs as adsorbents got the lowest value (0.68). Learning is to be effective if there is a statistically significant difference in chemical literacy and understanding of the concept of chemical bonds [10]. This can be shown from the increase in the pretest and posttest scores of students. Thus, learning MOFs as dye waste

adsorbents using an inquiry learning model facilitated by blogs can improve students' chemical literacy.

Students' chemical literacy ability increases due to the applied guided inquiry learning equipped with contextual-based learning. Contextual learning can train students to relate a material concept to everyday life, and optimize students' scientific literacy skills in the aspects of identifying scientific issues, explaining phenomena scientifically, and using scientific evidence [11].

In this study, the pretest and posttest aspects and indicators of chemical literacy used include aspects of knowledge and competence which are summarized in terms of content, context, and attitude aspects. In this study, the questions of chemical literacy developed include these three indicators. Questions regarding content aspects are answered with context and attitude aspects and vice versa. The science content is the implementation of chemical bonds in the synthesis of MOFs and the adsorption process of dye waste by MOFs. The scientific context is MOFs as adsorbents for dye adsorption. Meanwhile, the attitude of science includes responses to nature and the environment and how to overcome water pollution from dye waste.

From the results of the analysis obtained an n-gain score of 0.70 in the high category. In terms of content and context aspects of chemical literacy questions with indicators are able to describe the formation of MOFs and adsorption of dye waste by MOFs based on the concept of chemical bonds. Students are able to answer these questions well because students already understand the concept of chemical bonds, the chemical interactions involved in the process include dipole-dipole interactions, van der Waalls interactions and hydrogen bonds. The synthesis and adsorption processes presented on the blog can help students understand at a macroscopic level, so that students are able to answer questions on this aspect of the content well. Understand chemistry requires a lot of understanding, because chemistry consists of three levels [12].

The increase in chemical literacy is also influenced by the learning process. During the learning process in the classroom, researchers also encourage students to be creative and work together to collect information to construct their knowledge independently through discussion seeking information from various learning sources. Guided inquiry learning students do a lot of investigations using various learning resources so that it will stimulate students' chemical literacy skills, namely the ability to identify, analyze and draw conclusions from a phenomenon encountered so that students will understand the influence of science on technological developments and its implications for life [13].

The results of information seeking activities in the discussion process can develop students' chemical literacy competence in the form of the ability to use scientific evidence. Scientific evidence that has been obtained from various reliable sources is then interpreted and reduced by students which lead to the solution of the problem. The ability of students to interpret scientific data and evidence can be further developed through class discussion activities facilitated by the teacher, where students express opinions orally and in writing the findings of their group [14]. Aspects of attitude which includes the response of students to the environment related to the attitude of students to the phenomena that are around them. Attitude aspects are related to emotional factors which include interest and convenience in learning as well as student involvement in learning [15]. Attitude aspects in this study were measured using open-ended questions based on

context and content aspects. This means that the questions in each aspect are in harmony with each other.

Cases of waste pollution raised from events around students are presented on learning blogs. This can encourage students to increase their caring attitude towards the environment. This shows that in general students already know how to use chemistry to overcome environmental pollution. Guided inquiry learning can grow and develop students' scientific attitudes through the application of science by planning, conducting experiments, experiments, research, observing, analyzing, and concluding research results [16].

The context of Metal Organic Frameworks as adsorbents for adsorption of dye waste from the textile industry presented on the learning blog provides a special attraction for students. The implementation of the presented chemistry provides real examples of the scientific theories they get. This will make the material obtained more meaningful and can be remembered easily by students because it is related to everyday life.

4 Conclusion

The results showed that in general there was an increase in students' chemical literacy with an n-gain of 0.69 (medium). In response to the environment, students have the highest n-gain (0.75), while the chemical bond n-gain has the smallest value (0.65). This results indicates that the context of metal organic frameworks as adsorbents for dye adsorption provided through blogs can improve students' chemical literacy.

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