Developing Chamilo-Based E-Learning in Environmental Change Material to Enhance Students’ Scientific Literacy Skills

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Abstract. The main goal of learning science today is the realization of learners who are literate in science. Unfortunately, Indonesian scientific literacy skill is still low based on the assessment of OECD for three evaluation periods. Therefore this study aims to produce an electronic-based learning system in learning science using LMS Chamilo which is intended to enhance students' scientific literacy skills. This study is research and development (R & D) using the ADDIE model. Research findings indicated that (1) the Chamilo-based e-learning was feasible to implement in biology teaching based on experts judgment with a total score of 3.83 (very good) from environmental material expert and 3.22 (good) from learning media expert; (2) the Chamilo-based e-learning was accepted very well by users with a total score of 3.78 (very good) from biology teachers and 3.36 (very good) from students; (3) the Chamilo-based e-learning was effective in enhancing students' scientific literacy skills with n gain score of 0.74 (high criteria). Based on the results, it can be concluded that Chamilo-based e-learning is recommended to implement and to use in the biology learning process.

1. Introduction

The main goal of learning science today is the realization of a society that literate in science through understanding mathematics, physics, chemistry, biology, and technology. The demand for mastering scientific literacy either in national level or international level arises because all of the people are required to participate in solving real-world problems such as environmental pollution, climate change, natural disaster, and health [1].

The term scientific literacy was first revealed by Paul DeHart Hurd in 1958 which was used to describe the understanding of science and its applications in society. Scientifically literate people can engage with science issues and science ideas as reflective citizens based on the ability to explain phenomena scientifically, evaluate and design scientific inquiry, and interpret data and evidence scientifically [2]. It means that the students who are literate in science are those who have scientific knowledge and use it to explain the natural phenomena, get new knowledge through scientific inquiry, and draw conclusions based on scientific evidence.

Scientific literacy skills are evaluated internationally by the OECD once in three years and show that Indonesia is still below the average score of OECD during three evaluation periods (2009, 2012 and 2015), it causes Indonesia categorized as a country with low scientific literacy skills. This background then leads a demand to make the efforts of improving science learning quality in schools gradually and continuously.
The rapid progress of information, communication, and technology (ICT) offers a new learning innovation through the utilization of the internet with world-web-technology what it is called electronic-based learning (e-learning). The term "e-learning" is defined as learning without using printed teaching materials [3], the delivery of learning materials is conducted using an electronic course [4]. The use of e-learning offers the interactions between students and teachers from unlimited time and space through the asynchronous and synchronous learning network model [5] where the traditional instructional delivery system in the schools are limited to the classroom with the teacher giving speeches to students and students listening and taking notes [6]. With the progress of information and communication technology development, e-learning is emerging as the paradigm of modern education.

However, further development of e-learning is not just learning using an electronic course, but it necessary to build a rule and management of good teaching by using information technology [7], it is what is often referred to as a Learning Management System (commonly abbreviated to “LMS”). Through LMS, the teachers not only utilize the internet to give interesting information to the students but also can manage the learning activity through the served features inside it. One kind of LMS providing platform for e-learning and collaboration is Chamilo. It is free software focused on building e-learning portals easily, quickly and has attractive interfaces [8]. Chamilo is included in the 10 best open sources of LMS and takes place in the first rank in the course of development features, collaboration features, and instruction methods. Chamilo also takes place in the second rank in the administration features instead of the other open sources of LMS such as Moodle, LRN, eFront, Dokeos, Sakai, Latitude Learning, Canvas, OLAT and Totara [9].

Through the features available in Chamilo, the teachers can present distant biological objects like pollution and environmental damage occurring in various regions or hard-observed biological phenomena like global warming, polar ice melt, depletion of the ozone layer, and the acid rain process. These objects and phenomena can be presented in the form of pictures, animation, or video. These advantages will make easier for students to understand biological concepts and relate them to various phenomena and current scientific issues, draw conclusions based on evidence, make decisions, and apply them in their daily life. Moreover, the teachers can manage in distributing learning materials, building communication, giving the task, doing the test, monitoring student’s learning progress and other aspects of learning management. As it provides a pleasant learning experience, the students will be more interested in learning biology. The learning can also give positive effects related to their scientific literacy skills.

Based on the explanation above, this study aims to develop Chamilo-based e-learning in environmental change material to enhance students’ scientific literacy skills.

2. Method

2.1. Research Type and Design
This study is Research and Development (R&D) with the ADDIE model. Research and Development is the systematic study of designing, developing and evaluating instructional programs, processes, and products that must meet the criteria of internal consistency and effectiveness [10]. The systematic process in this model was represented in the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) which stood for the important components in the process of creating the instructional design [11]. The ADDIE model is an iterative instructional design process where the results of the formative evaluation of each phase might lead the instructional designer back to any previous phase. The end of one phase was the starting product of the next phase [12].

2.2. Data Collection and Analysis Technique
The developed e-learning was evaluated by the experts and the users and it was implemented to the students to find out its effectiveness in enhancing scientific literacy skills. The evaluation by experts and users were measured using feasibility assessment sheets. The data of evaluation was calculated using a
Likert scale 1-4 and analyzed based on the scoring system and the criteria in Table 1[13] to determine the level of feasibility of e-learning devices.

Table 1. Score interpretation (conversion quantitative data to qualitative)

| Formula                          | Interval Score | Criteria       |
|----------------------------------|----------------|----------------|
| \(M_i + 1.5SD_i \leq M \leq M_i + 3.0SD_i\) | \(3.25 \leq M \leq 4.00\) | Very Good      |
| \(M_i + 0SD_i \leq M \leq M_i + 1.5SD_i\) | \(2.50 \leq M \leq 3.25\) | Good           |
| \(M_i - 1.5SD_i \leq M \leq M_i + 0SD_i\) | \(1.75 \leq M \leq 2.50\) | Not Good       |
| \(M_i - 3.0SD_i \leq M \leq M_i - 1.5SD_i\) | \(1.00 \leq M \leq 1.75\) | Very Not Good  |

Scientific literacy skills were measured using an essay instrument formulated following the indicators of the Program for International Student Assessment (PISA) 2015. Indicators of scientific literacy are developed based on the science competency aspect, including (a) explain phenomena scientifically - recognizing, offering and evaluating the explanations for various natural things and technological phenomena; (b) evaluate and design scientific inquiry - describing and evaluating scientific investigations and proposing ways to answer questions scientifically; (c) interpret data and evidence scientifically - analyzing and evaluating data, claims, and arguments in various representations and drawing appropriate scientific conclusions. The test was carried out using one group pretest-posttest design and the data of test were calculated using the formula of the n-gain score [14]:

\[
< g > = \frac{S_f - S_i}{S_{\text{max}} - S_i}
\]

Noted:
- \(S_f\) = Post-test score
- \(S_i\) = Pre-test score
- \(S_{\text{max}}\) = maximum score

The acquisition of n-gain scores was analyzed based on the criteria system in table 2 to determine the category of enhancement in students' scientific literacy skills.

Table 2. The n-gain interpretation score

| Range          | Criteria |
|----------------|----------|
| \((<g>) < 0.3\) | Low      |
| \(0.3 \leq (<g>) < 0.7\) | Medium  |
| \((<g>) \geq 0.7\) | High    |

3. Result and Discussion
The produced product in this research and development is e-learning in environmental change material. E-learning devices are developed using LMS Chamilo version 1.11.8 for PHP 7.0.x or later. Chamilo is free software providing a platform for e-learning and collaboration. It is what is often referred to as a “Learning Management System”, a popular term used to describe any kind of software platform designed to facilitate the management and delivery of courses and the monitoring of students’ progress [15].

The developed e-learning consists of four main components including homepage, courses catalog, my courses, and course homepage. There are two types of homepage. The first is homepage before login that displays login navigator, usage instructions, learning resources (containing learning videos), list of contents, and developer biography. The second is homepage after login that displays the most popular courses, user profiles, personal agenda, progress, social networks, and the number of users online.
The courses catalog displays all content in e-learning which is classified into four categories, namely learning materials, practical worksheets, articles, and tests. All content in e-learning is related to environmental change material. My courses displays a list of courses that have been subscribed by students. To access a course, click on the course name and the course home will appear. The course homepage displays menus in the form of course descriptions, agendas, learning paths, announcements, users, chat, assignments and glossary. E-learning users simply click on one of the menus as needed. In detail, the developed e-learning can be accessed on the website chamilogi-learning.com.

The development of Chamilo-based e-learning involves the experts and users to provide an evaluation of the developed e-learning devices. Furthermore, e-learning is implemented for students to find out its effectiveness in enhancing scientific literacy skills. The assessment results are shown in the following explanation.

3.1. Evaluation Result of Experts

3.1.1. Evaluation Result of Environmental Expert. The evaluation of the material aspect was carried out by Dr. Suhartini, M.S., an environmental expert in Biology Education, Graduate Program, Yogyakarta State University. The material evaluation is reviewed based on four aspects, including the suitability of material, material presentation techniques, language and suitability of evaluation form. The evaluation result of an environmental expert can be seen in table 3.

| No  | Assessment Aspect          | Score | Criteria     |
|-----|----------------------------|-------|--------------|
| 1   | Suitability of material    | 3.86  | Very Good    |
| 2   | Material presentation techniques | 3.80  | Very Good    |
| 3   | Language                   | 4.00  | Very Good    |
| 4   | Suitability of evaluation form | 3.67  | Very Good    |
|     | **Average**               | 3.83  | Very Good    |

The evaluation result by environmental expert states that the material concept is correct and following the core competencies (KI) and basic competencies (KD). It is presented clearly, systematically and interestingly. The language chosen in explaining the concept is communicative, helps the students to understand learning material easily. The type of test used is also under the material presented. However, there are some typing errors needed to be corrected and some environmental laws that must be updated. Based on table 3, the average score of all aspects given by material experts is 3.83. It can be concluded that the presented material in e-learning is feasible to use in biology teaching with very good criteria.

3.1.2. Evaluation Result of Learning Media Expert. The evaluation of the media aspect is conducted by Dr. Slamet Suyanto, M.Ed., an education technology expert in Biology Education, Graduate Program, Yogyakarta State University. The media evaluation is reviewed based on eight aspects, including quality of content, quality of pictures, videos, and animations, creativity in expressing the idea, display, language, interaction, usability, and compatibility. The evaluation result of learning media expert can be seen in table 4.
Table 4. The evaluation result of learning media expert

| No | Assessment Aspect       | Score | Criteria   |
|----|-------------------------|-------|------------|
| 1  | Quality of content      | 3.33  | Good       |
| 2  | Picture, video, animation | 3.00 | Good       |
| 3  | Creativity in expressing idea | 4.00 | Very Good  |
| 4  | Display                 | 3.50  | Very good  |
| 5  | Language                | 3.00  | Good       |
| 6  | Interaction             | 3.00  | Good       |
| 7  | Usability               | 3.00  | Good       |
| 8  | Compatibility           | 3.00  | Good       |
|    | Average                 | 3.22  | Good       |

The evaluation result of learning media expert states that e-learning has functioned well. It has an attractive interface and uses communicative language. Various kinds of e-learning content such as learning materials, learning videos, environmental articles, competency tests, and discussion forums are presented creatively. Moreover, e-learning compatibility is good; it can be accessed via personal computers and smartphones, making it easier for students to use. Based on table 4, the average score of all aspects given by learning media expert is 3.22. From this, the researcher concludes that e-learning media is feasible to use in biology teaching with good criteria.

However, there is a feedback from learning media expert. The expert says that it is necessary to add the instructions of use, so the new students can be easier to access the material in e-learning.

3.2. Evaluation Result of Users

3.2.1. Evaluation Result of Biology Teachers. The Chamilo-Based e-learning was evaluated by Mr. Kusnardi S.Pd and Mrs. Lilik Tri Utami S.Pd as biology teachers of SMA N 1 Wates, Yogyakarta. The aspects evaluated by biology teachers include the material/content, media, language, and learning. The evaluation results of biology teachers can be seen in table 5.

Table 5. The evaluation result of biology teachers

| No | Assessment Aspect | Score | Criteria |
|----|-------------------|-------|----------|
| 1  | Material/content  | 4.00  | Very Good|
| 2  | Media             | 3.75  | Very Good|
| 3  | Language          | 3.67  | Very Good|
| 4  | Learning          | 3.71  | Very Good|
|    | Average           | 3.78  | Very Good|

The evaluation result of biology teachers states that e-learning content is interesting to learn. The material is arranged systematically and equipped with images and videos, support students in understanding learning materials. E-learning design is good and easy to operate via personal computers and smartphones. Moreover, e-learning can help teachers to convey more interesting learning materials to students. Through e-learning, the teachers can manage the learning materials and distribute them to the students. It also helps the teachers to monitor students’ progress in learning biology. Lastly, e-learning helps the students to learn the materials independently; students can access the learning material
anytime anywhere making the learning process more flexible. Overall, it can be concluded that e-learning can improve the quality of learning.

Based on table 5, the average score of all aspects scored by biology teachers is 3.78 (very good), meaning that e-learning media is feasible to use in biology teaching.

3.2.2. Evaluation Result of Students’ Responses. The evaluation of students’ responses to Chamilo-based e-learning is conducted by giving a questionnaire to thirty-two students of the tenth grade of SMA N 1 Wates, Yogyakarta. The questionnaire contains the statements categorized into seven aspects; including interest of content, interest of media, language, usability, compatibility, flexibility, and interaction. The evaluation result of students’ responses can be seen in table 6.

| No | Assessment Aspect                                | Score | Criteria   |
|----|--------------------------------------------------|-------|------------|
| 1  | Interest of content                              | 3.55  | Very Good  |
| 2  | Interest of media                                | 3.54  | Very Good  |
| 3  | Language                                         | 3.16  | Good       |
| 4  | Usability (simple to operate)                    | 2.98  | Good       |
| 5  | Compatibility (easy to run on PC/tablet/ smartphone) | 3.13  | Good       |
| 6  | Flexibility (can be accessed anytime and anywhere) | 3.78  | Very Good  |
| 7  | Interaction (chat, online discuss)               | 3.34  | Very Good  |

Average 3.36 Very Good

The evaluation result of students’ responses state that the design of environmental change material presented in e-learning is very good. The support of images and videos on the materials makes it easier to understand. Moreover, e-learning has an attractive interface. It can be accessed not only through personal computers but also through smartphones. It makes students easier to learn; they do not have to bring a lot of books. Only with a smartphone, they can still access the materials anytime anywhere. Through e-learning, they can create a group of discussion to discuss assignments from the teacher and can also ask the teacher through a private chat when they cannot meet the teacher face to face. In other words, the use of e-learning provides new learning experiences for students.

Based on table 6, the average score given by students is 3.36, meaning that the development of Chamilo-based e-learning can be accepted by students very well. However, some students find some difficulties in using e-learning, especially in accessing the material and uploading the assignments. This case can be a reason why the developers need to improve e-learning more easily or at least add the instructions of use on each page.

3.3. The Effectiveness of Chamilo-Based E-Learning in Enhancing Students’ Scientific Literacy Skills

The Chamilo-based e-learning is implemented to 32 students of the tenth grade of SMA N 1 Wates Yogyakarta to find out its effectiveness in enhancing students’ scientific literacy skills. The scientific literacy skills are measured based on the pre-test and post-test results using n-gain score analysis. The measurement results of scientific literacy skills can be seen in Table 7.

| No | Explanation             | Pre-test | Post-test |
|----|-------------------------|----------|-----------|
| 1  | Total number of students | 32       | 32        |
| 2  | Lowest score            | 38.25    | 75.00     |
| 3  | Highest score           | 65.00    | 100.00    |
| 4  | Group’s average         | 52.08    | 87.52     |

\( n\text{-gain} \) score 0.74

The category of \( n\text{-gain} \) score High
Based on Table 7, the n-gain score gets 0.74. It means that there is an improvement of students’ scientific literacy skills after using Chamilo-based e-learning in biology teaching with the high category. The spread of categories of scientific literacy skill improvement in 32 students is represented in the pie chart below (figure 1).

![Figure 1](image1.png)

**Figure 1.** The spread of categories of students’ scientific literacy skills improvement after using Chamilo-based e-learning in the learning process.

Based on Figure 1, it can be explained that 56% of the students (18 students) enhance their scientific literacy skills with the high category and 44% (16 students) enhance their scientific literacy skills with the medium category. In other words, there is a big difference in the range of students’ scientific literacy skills. The difference in students' scientific literacy skills enhancement can occur because of some reasons such as students’ potential reasons, the characteristics of social areas, and the various cultures of the students in Indonesia. These reasons give an effect on the aspects of learning and the students’ scientific literacy skills as well. Based on the results, there is the enhancement in each scientific literacy competency after using Chamilo-based e-learning in biology teaching represented in the chart below (figure 2).

![Figure 2](image2.png)

**Figure 2.** The chart of the enhancement of the scientific literacy competencies

The chart in figure 2 shows that the enhancement of Explain Phenomena Scientifically aspect is 39.06%, the enhancement of Evaluate and Design Scientific Inquiry aspect is 36.16%, and the enhancement of Interpret Data and Evidence Scientifically aspect is 35.96%. The increase of these three aspects is stimulated by the use of text, picture, video, and animation presented in the interactive learning
media like e-learning. It can help the students in understanding the content learned [16]. Besides, Chamilo-based e-learning provides the environmental pollution problems happened in the society, so the students can understand the situations of life in which it does not only focus on the school life, but also focus on daily life, so this kind of e-learning will stimulate the students to relate their learned knowledge with the problems existed in the society.

The Chamilo-based e-learning also presents various scientific phenomena such as a mass of fish death in the river, acid rain, depletion of the ozone layer, hotter weather, explosion of the particular animal population like rats, and other phenomena. Presenting the scientific phenomena will train the students to collect various information, data, and evidence from many resources such as news, journals, or the internet to explain these scientific phenomena based on the correct data and evidence. Moreover, they can also interpret the data and evidence they’ve obtained to strengthen their arguments. Chamilo-based e-learning also provides a worksheet to train the students in arranging and using the correct procedure in conducting some investigations scientifically.

Fundamentally, the development of Chamilo-based e-learning is not only intended to improve students' scientific literacy skills but also to help teachers in collecting and organizing the learning materials online. The e-learning is also helpful in sharing the materials to the students, so they do not have to carry a pile of books to school. The use of e-learning can offer much time-saving by taking over a range of repetitive administrative tasks and allowing teachers to focus on supporting students. The spare time, then, can be used to create many types of teaching materials. More importantly, it can provide students with a range of motivational tools supporting the effectiveness of independent study at their own space and as a purpose to interact more with their teachers and fellow students.

The use of e-learning in biology teaching has advantages and disadvantages. The advantages of using e-learning are: (a) providing complete learning materials accompanied by practice questions with attractive displays so they can easily be understood by students; (b) facilitating teachers to monitor the students' learning progress because it is equipped with students’ developmental data analysis; (c) facilitating the students to review the learning materials anytime anywhere; (d) facilitating the teachers and the students to interact each other through the forums, so it makes easier for students to ask teachers when they cannot meet face to face, (e) being more efficient in time, place, and cost.

In conclusion, the use of e-learning is intended to improve the quality of learning. The results of some studies state that e-learning can increase student motivation [17] [18]; give positive impact to academic performance [19]; improve students’ academic achievement and creativity [20]; Improve students’ knowledge and skills [21]; improve the quality of practical training; and provide a better understanding of learning materials [22]. Indeed, e-learning is not intended to replace conventional classroom settings, but it can be a complementary learning process related to learning materials possibly can be accessed online [23].

The disadvantages of e-learning are: (a) requiring additional devices such as personal computers, smartphones, or tablets; (b) only be used if devices definitely connect to internet with stable networks; (c) having negative effect on student communication skills (students may have excellent knowledge in academics but they may not have good skills to convey their knowledge to others); (d) lacking of effectiveness for practical learning materials like observing microorganism directly using a microscope; (5) being less effective for the teachers and the students who are not familiar with or lacking the knowledge of internet.

4. Conclusions
Based on the result of the research and development, it could be concluded that: (1) the Chamilo-based e-learning was feasible to implement in biology teaching based on experts judgment with a total score 3.83 (very good) from environmental material expert and 3.22 (good) from learning media expert; (2) the Chamilo-based e-learning was accepted well based on users’ judgment with a total score 3.78 (very good) from biology teachers and 3.36 (very good) from senior high school students; (3) the Chamilo-based e-learning was effective in enhancing students' scientific literacy skills with n gain score of 0.74 (high category).
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