Online-based Physics Learning to Provide Four Dimensions of Knowledge to Teacher Training Program Students

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Abstract. The purpose of the study is to describe the effectiveness of online-based physics learning to provide four dimensions of knowledge to teacher training program students. This type of research is quasi-experimental with a time-series design. Effectiveness is seen from the four dimensions of student knowledge and response. The manipulation variable is online-based physics learning and mastery of knowledge is the dependent variable. Research subjects were 40 students of the Physics Teacher Training Program at Universitas Negeri Surabaya. Six Physics modules are discussed regularly. Assessment of four dimensions of student knowledge and responses using a Likert scale (1-5). Data analysis uses descriptive statistics. Learning is effective if the average value of mastery of each dimension of knowledge ≥ 3.1 (scale 0-5) in each discussion module with a fixed or upward trend. Student responses are effective if the percentage is obtained by ≥ 61%. The results are: 1) the average score of students' knowledge dimensions (factual, conceptual, procedural, and metacognitive) is ≥ 3.1 2) Student responses are ≥ 61%. The results showed that online-based physics learning is effective can provide four dimensions of knowledge to Teacher Training Program Students and get a positive response.

1. Introduction

The idea and scientific investigation to test the physical properties of the universe is known as Physics. Mastery of Physics concepts requires learning that can provide four dimensions of knowledge, namely factual, conceptual, procedural, and metacognitive. These four dimensions of knowledge can be provided through online-based learning [1]. In this ever-changing world, students are required to be able to absorb new ideas, filter and interpret information, apply knowledge, and solve various life problems. This complex 21st century requires students' thinking skills because they are required to think and reason coherently [2]. At present student-centered learning is becoming a trend compared to teacher-centered learning. Students are given more opportunities to explore questions, develop ideas and test hypotheses, so they can reflect on their learning, gain a deep understanding of the concepts being learned and become better thinkers. Physics teaching materials must be integrated according to the meaning of the nature of Physics and be able to accommodate the higher-order thinking skills of students. Higher-order thinking skills aim to practice thinking skills and provide learning experiences to students who do not merely repeat information or facts [3].

Educational applications with online-based learning are now starting to develop. Students can access knowledge from textbooks besides that they can also access learning from outside the school. Teachers and students can get a lot of information that is not limited even they can access many
libraries throughout the world. Information with various media can be accessed through the internet, making it a library without limits. The website is used by students and teachers in classroom learning to access information from various sources on the internet. Some educational institutions utilize the development of this application for online-based learning by holding schools or online courses. Even the Ministry of Research, Technology and Higher Education has made guidelines for conducting online lectures at universities [4]. One of the competencies of professional teachers is having the ability to develop and utilize information technology in learning. Also, the current learning trend is to reduce the use of paper in schools. Therefore the use of computers in learning becomes a necessity in schools, especially online-based learning. For online-based learning to attract students, it is necessary to consider that teaching materials are not just digital-based, but the packaging must be more interesting than paper-based ones. The use of digital teaching materials is very potential to fill them because it allows teachers to integrate multimedia (text, images, sound, and animation) into interactive digital teaching materials.

Online-based learning can be filled with materials that are packaged interactively so that it makes students more comfortable and encourages students to read and understand. Materials in online-based learning can be equipped with audio, music, video, and animation features which are certainly better than printed books that only have pictures, narration, and graphics [5]. Presentation of materials in online-based learning can display a variety of physics phenomena more real so that it can provide four dimensions of knowledge, namely factual, conceptual, procedural, and metacognitive. The use of computers can provide not only the cognitive abilities of students but can be used to practice the ability to conduct experiments on students by integrating virtual laboratories [6]. The use of online-based learning provides several advantages are reducing the use of paper, communicative, can be accessed anytime and anywhere [7]. Physics symptoms video presented in online-based learning will reinforce students four dimension knowledge are factual, conceptual, procedural, and metacognitive.

Mastery of knowledge can be approached through four dimensions, namely factual, conceptual, procedural, and metacognitive. Factual contains the basic elements that must be known when solving a problem. These elements are usually in the form of symbols that are combined in several real references or a series of symbols that carry important information. Conceptual includes categories and classifications and relationship arrangements (schemes, mental models, implicit or explicit theories) that present how specific materials are arranged and constructed, functioned and arranged more systematically. Procedural is the process of how to do something, such as algorithms, techniques, and methods as a whole known as a procedure or a series of steps. Metacognitive is the ability to control the cognitive aspects, namely controlling the six levels of cognitive aspects (memory, understanding, applied, analysis, synthesis, and evaluation). Online-based physics learning developed in the research focuses on training the mastery of physics knowledge through four dimensions, namely factual, conceptual, procedural, and metacognitive so that it can be developed optimally. The researcher believes that online-based physics learning can provide better learning outcomes for students.

2. Method
This research is a quasi-experimental type with a time-series design. Dependent variables in groups are measured before and after treatment to have their impact using repeated measurements over a certain period. [8]. Online-based learning is used as a manipulation variable in research, while the dependent variable is mastery of the four dimensions of knowledge (factual, conceptual, procedural, and metacognitive) in physics whose measurements are based on clarity, breadth, depth, systematics, and truth of concepts. The definitions used for the four dimensions of knowledge are: 1) Factual are the basic elements using symbols or a series of symbols that carry important information about a phenomenon; 2) Conceptual is a relationship structure that presents structured material privileges more systematically; 3) Procedural is the process of doing something that presents a sequence of steps; 4) Metacognitive is the ability to control the realm of cognitive aspects. which controls six levels of cognitive aspects (memory, understanding, application, analysis, synthesis, and evaluation). Repeated measurements in this study were only carried out after treatment because they used performance tests.

The procedure of this research is to apply physics-based online learning using the link: https://ppgspada.brightspace.com/d2l/le/content/18562/Home. The main features provided are material
modules, discussion forums, assignments, and tests. Mastery of the four dimensions of Physics knowledge is measured through assessment of task performance and student activities in discussion forums. Next students are given a questionnaire to get their responses to the learning process. The material module is a module that contains a description of the material by the topics discussed along with supporting files (presentations and videos of phenomena). Assignments are a series of steps that students must take to master the four dimensions of Physics knowledge by the topics discussed. Six modules are covered in learning which covers all Basic Physics topics. The research subjects were 40 students of the Physics Teacher Training Program at Surabaya State University.

Performance tests and questionnaires are used to collect research data. Likert scale with a scale of 1-5 (very less = 1, less = 2, enough = 3, good = 4, and very good = 5) is used as a student performance score for mastery of the four dimensions of physics knowledge. Questionnaire student responses to the learning process also use a Likert scale with the same criteria.

Data analysis in this study uses quantitative descriptive. The description of effectiveness is based on the average score of students' mastery of each dimension of knowledge, and student responses to the learning process. If the average value of each dimension of student knowledge ≥ 3.1 (scale 1-5) in each discussion topic with a fixed or upward trend, then learning is effective. Student responses are obtained by adding up all the average scores given by students divided by the maximum score multiplied by 100%, and effective learning, if the percentage obtained, is ≥ 61%.

3. Results

3.1. Implementation in learning
Physics material is studied by students through material modules that are already available on the web. One feature on the web is the discussion forum used for online interaction in learning between instructors and students. The instructor gives a discussion topic about one topic and the students give answers that are uploaded directly on the web. Examples of interactions between instructors and students are shown in Figure 1.

![Figure 1. Examples of online interactions between instructors and students](image)

Figure 1 shows that the instructor triggers students in a discussion forum on a topic of Physics so students explore their knowledge based on the modules they have learned from the web. Then students upload answers based on their mastery of knowledge that can be measured based on clarity, breadth, depth, systematics, and truth of concepts.

3.2. Mastery of factual knowledge
The score of mastery of factual knowledge from online based physics learning using 6 material modules for Physics topics with sequential periods is shown in Figure 2.
Figure 2. The average score of factual knowledge

Figure 2 shows that the average score of factual knowledge of students is ≥ 3.1 with a range of scores (4.14-4.48) and has a slight upward trend. These results indicate that online-based Physics learning can provide factual knowledge to students with good results.

3.3. Mastery of conceptual knowledge

The score of mastery of conceptual knowledge from online based physics learning using 6 material modules for Physics topics with sequential periods is shown in Figure 3.

Figure 3. The average scores conceptual knowledge

Figure 3 shows that the average score of conceptual knowledge of students is ≥ 3.1 with a range of scores (3.94-4.44) and has a slight upward trend. These results indicate that online-based Physics learning can provide conceptual knowledge to students with good results.

3.4. Mastery of procedural knowledge

The score of mastery of procedural knowledge from online based physics learning using 6 material modules for Physics topics with sequential periods is shown in Figure 4.

Figure 4. The average scores of procedural knowledge

Figure 4 shows that the average score of procedural knowledge of students is ≥ 3.1 with a range of scores (3.88-4.24) and has a slight upward trend. These results indicate that online-based Physics learning can provide procedural knowledge to students with good results.
3.5. Mastery of metacognitive knowledge
The score of mastery of metacognitive knowledge from online based physics learning using 6 material modules for Physics topics with sequential periods is shown in Figure 5.

![Figure 5](image)

**Figure 5.** The average score of metacognitive knowledge

Figure 5 shows that the average score of metacognitive knowledge of students is ≥ 3.1 with a range of scores (3.74-4.08) and has a slight upward trend. These results indicate that online-based Physics learning can provide metacognitive knowledge to students with good results.

3.6. Student responses to the learning process
The effectiveness of online-based Physics learning in terms of technical aspects and aspects of learning by student responses can be shown in Figure 6.

![Figure 6](image)

**Figure 6.** Effectiveness of online-based physics learning based on student responses

The results presented in Figure 6 show that the percentage of effectiveness based on student responses was ≥ 61%. Students' responses to aspects of learning that are related to the ability of factual knowledge, conceptual knowledge, procedural knowledge, and meta-cognitive knowledge also correspond to the results obtained from their performance tests. The results of the study indicate that online-based Physics learning is effectively used to provide four dimensions of knowledge (factual, conceptual, procedural, and metacognitive).

4. Discussion
Online-based physics learning can be done by using a website for instructor interaction with students. The main features on the web can be in the form of material modules, discussion forums, assignments, tests, and are equipped with other supporting features. The website functions as a guide that has the main page and several sections that contain general guidelines and specific guidelines for each Physics topic. The tools needed to give students four dimensions of knowledge (factual, conceptual, procedural, and metacognitive) are available on the website by providing material modules and discussion forums. Conceptually learning using a web site can be used to obtain four dimensions of knowledge. Human resources in learning can be managed by taking into account important factors that
must be considered including the environment, information and communication systems [9]. Logical reasons show the correspondence between managing knowledge with electronic learning, which together expresses the professional development of the scientific community [10]. Videos supporting that feature physics phenomena enable students to make observations, so students can continue to explore factual, conceptual, procedural, and metacognitive knowledge. Students' mastery of factual, conceptual, procedural, and metacognitive knowledge is presented in Figure 2-5. Managing knowledge needs to pay attention to how to select, store and apply that knowledge [11]. The features provided on this website allow well-developed learning scenarios, learning materials, learning media, and learning environments.

Online based physics learning can provide four dimensions of excellent knowledge to students. All score dimensions of student knowledge in consecutive periods for the discussion of 6 material modules show continuity and tend to increase although small. Each specific topic is discussed together in a discussion forum before they make an assignment report. They can share information to get the four dimensions of knowledge optimally. Sharing knowledge among students is needed in optimally managing the class [12]. Evaluation of each task allows for an increase in individual knowledge. Detailed analysis relevant to individual assignments will be useful to produce better assignments [13]. The results of studies that have been done get that online learning can train students' process skills [14] and [15], also learning with e-learning can improve physics learning outcomes [16].

Student responses to online-based Physics learning are very good (Figure 5). All components (technical aspects and learning aspects) get a good response from students. Overall the percentage of effectiveness based on student responses ≥ 61% which means that online-based Physics learning effectively provides four dimensions of knowledge (factual, conceptual, procedural, and metacognitive). The good student response is mainly due to the flexible online learning process that can be done anytime, anywhere, and in any condition [17].

5. Conclusion
Online-based Physics learning is effective in terms of technical and learning aspects. Online-based physics learning can provide four dimensions of knowledge (factual, conceptual, procedural, and metacognitive). Knowledge mastery is assessed in terms of clarity, breadth, depth, systematics, and truth of concepts. Student responses to online physics-based learning are very good, namely: technically it can be operated anytime and anywhere, and from the learning aspect because it provides mastery of the four dimensions of knowledge. The online-based learning process is effective for giving four dimensions of knowledge on physics teacher training program students.

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