Online-based Learning to Train Students Critical Thinking in Physics Teacher Training Programs

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Abstract. The research objective is to describe the effectiveness of online-based learning to train students’ critical thinking in physics teacher training programs. The elements of critical thinking are: analyzing, evaluating, implementing, generating ideas, and expressing ideas. This type of research is quasi-experimental with a time-series design. Effectiveness is seen from the ability to train the elements of critical thinking and student responses. Manipulation variable is online-based physics learning and the dependent variable is an element of critical thinking. The research subjects were 40 students of the Physics teacher training program at Universitas Negeri Surabaya. The elements of critical thinking and student responses are assessed using a Likert scale. Descriptive statistics are used to analyze data. Learning is effective if the average value of critical thinking elements ≥ 3.1 (scale 0-5) for each module is discussed with a fixed or upward trend. Student responses are effective if the percentage is ≥ 61%. The results obtained: 1) the average score of critical thinking elements ≥ 3.1 2) The percentage of student responses ≥ 61%. These results indicate that online-based learning can effectively train students’ critical thinking in the Physics Teacher Training Program and get a positive response.

1. Introduction

Physics is the result of ideas and scientific investigations that test the physical properties of the universe. The concept of Mastery of Physics requires learning that trains critical thinking and scientific processes, namely the process of thinking and acting to find, develop, and apply the knowledge that involves intellectual, psychomotor, and affective based on students' basic abilities [1]. Efforts to ask questions and answer questions systematically to produce a coherent and credible explanation is called critical thinking [2]. Students are in a fast-changing world, so they must be able to absorb new ideas, filter information and interpret it, apply knowledge, and solve life problems. The 21st century is so complex that critical thinking skills become very important because students are forced to develop coherent ways of thinking and reasoning [3]. Critical thinking is a learning process that requires students to make conclusions or solve problems. Students can solve problems if the learning process provides opportunities for students to think critically, that is a process that is self-directed, self-monitored, and self-corrected. Someone who thinks critically can be seen from the way of thinking that is clear, accurate, relevant, logical, broad, precise, significant, complete, fair, and profound [4]. People who think critically will consistently live rationally, empathically, and realize that the human mind is imperfect when left unchecked. Some elements of critical thinking are: analyzing, evaluating,
applying, generating ideas, and expressing ideas [5]. Currently, learning trends are student-centered learning. Learning provides opportunities for students to explore questions, develop and test hypotheses. Teachers provide more opportunities for students to reflect on their learning, gain a deeper understanding of concepts. Learning becomes more integrated and makes students critical thinkers. Science learning emphasizes the process, so that science teachers avoid memorizing and only conveying small facts from science [6]. Physics is the part of science that studies natural phenomena related to matter and energy, which play an important role in the development of technological progress and balance with nature. Physics teaching materials must be integrated with the meaning of the nature of Physics and accommodate students’ thinking skills to a higher level. Higher-order thinking skills are a fundamental goal in the educational assessment that aims to introduce students’ thinking skills and learning experiences that are more than just repeating information or facts [7].

Educational applications with online learning are now starting to develop. Students can access knowledge apart from textbooks and can access learning from outside the school. Teachers and students get a lot of unlimited information by accessing it from several libraries around the world. The internet can display information with a variety of media (including print, video, music, and sound recordings) so that the internet becomes an unlimited library. Students and teachers can carry out learning in class by accessing various sources of information on the internet through websites. Some educational institutions have conducted 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 [8]. One of the competencies of professional teachers is having the ability to develop learning that utilizes information and communication technology. The current learning trend is to reduce the use of paper in schools, so that the use of computers in learning becomes a necessity, both for the learning process (e-books, media, learning resources, etc.) and evaluating learning outcomes (online and offline exams). One thing to consider in online learning is that preparing digital teaching materials with packaging is more interesting than paper-based. Digital teaching materials have this potential because it allows teachers to integrate multimedia (text, images, sound, and animation) into digital teaching materials.

The use of e-books in online-based learning has the potential to encourage students to read and understand them interactively and make them more comfortable. Although printed books have pictures, narratives, and graphics, e-books can be equipped with audio, music, video, and animation features [9]. With these features, e-books can be used to practice scientific process skills, which are the skills needed in scientific inquiry when students learn science through cognitive, psychomotor, and affective processes [1]. Printed books describe specific subjects or fields of study, systematically selected based on specific objectives, and used to help students learn in school [10]. Computers can be operated more than students' cognitive abilities and can integrate virtual laboratories, so students can conduct experiments [11]. The advantage of using online-based learning is that it can reduce the use of paper [12] and can be more communicative. Video can be used to train elements of the science process skills (observing, classifying, inferring, predicting and communicating). Also addition, it can be used to develop critical thinking (analyzing, evaluating, applying, generating ideas, and expressing ideas).

Online-based physics learning requires a scientific approach to practice students' critical thinking. Therefore, videos and images are displayed in the learning material to train students to think critically. Implementation of learning is focused on critical thinking, so that through this learning students are allowed to think and process through the provision of learning material, discuss, solving problems, and provide feedback. Online-based physics learning applied in this research is focused on training in critical thinking with elements which include analyzing, evaluating, implementing, generating ideas, and expressing ideas, so students' critical thinking can develop optimally. The ability to think critically is assessed in terms of relevance, logic, breadth, and depth of thought. Through online-based physics learning, researchers believe that student learning outcomes in physics will be better.

2. Methodology of Research
This type of research is quasi-experimental with time-series design, which measures the dependent variable in the group before and after treatment to determine the impact obtained by repeated measurements at a certain period. [13]. The manipulation variable in this research is online-based
physics learning, while the dependent variable is the ability to think critically (analyze, evaluate, apply, generate ideas, and express ideas). The definition is given to the elements of critical thinking [5]: 1) Analyzing is to learn something to identify the elements or relationships between the elements; 2) Evaluate is examining and responding critically to materials, procedures, or ideas, and evaluating them based on specific objectives, standards or criteria; 3) Apply is using ideas, processes, or skills in new situations; 4) Generating ideas is expressing thoughts that express originality, speculation, imagination, a personal perspective, flexibility in thinking, discovery or creativity; 5) Expressing ideas is presenting initial and logical ideas using language that is appropriate for the audience. In this study, repeated measurements were carried out after the implementation of online-based physics learning using performance tests.

The procedure of this research is to apply online-based physics learning that has features of application usage guides, material modules, discussion forums, assignments, and online tests. Critical thinking abilities are measured by evaluating student performance in discussion forums and assignments given to students. Application usage guidelines are explanations that contain explanations of the use of online applications used and activities that students must carry out in online-based physics learning. The material module is a description that contains material summaries, reference book links, video phenomenon links, and task assignments that students must do. Discussion forums are means provided for instructors and students to discuss the material of certain fields of physics. Assignments are a series of steps that students must take to master certain areas of physics according to the topics discussed. Online tests are tests that are provided online for both formative and summative tests. There are six modules discussed in online-based physics learning, each module consisting of four learning activities with one physics topic. The research subjects were 40 physics students from teacher training programs at Surabaya State University.

Data collection techniques using performance tests and questionnaires. Critical thinking skills scores are obtained from the assessment of activities in discussion forums and student assignments using a Likert scale (very less = 1, less = 2, enough = 3, good = 4, and very good = 5). A Likert scale with the same criteria was used to questionnaire student responses to online-based learning.

Data analysis using quantitative descriptive. Description of effectiveness is obtained based on the average score of students' mastery of each element of critical thinking, and student responses to the online-based learning process. Learning is declared effective if the average value of each element of student's critical thinking ≥ 3.1 (scale 0-5) in each discussion topic with a fixed or upward trend. Student responses to online-based learning are declared effective if the percentage obtained is ≥ 61%.

3. Result of Research

3.1. Ability to Analyze

The ability of students to analyze online-based physics learning for six physics modules, each of which consists of four learning activities with sequential periods is shown in Figure 1.

![Figure 1. The average score of students' ability to analyze](image-url)
Figure 1 shows that for the ability to analyze, students have an average score of ≥ 3.1 with a range of scores (4.15-4.41). So that online-based physics learning is effective to train analytical ability for students.

3.2. Ability to evaluate
The ability to evaluate in online-based physics learning for six modules, each of which consists of four learning activities with sequential periods is as shown in Figure 2.

![Figure 2](image)

**Figure 2.** The average scores of students’ evaluation abilities

Figure 2 shows that for the ability to evaluate, students have an average score of ≥ 3.1 with a range of scores (4.05-4.32). So that online-based physics learning is effective to train the ability to evaluate for students.

3.3. Ability to apply
The ability of students to apply online-based physics learning for six physics modules, each of which consists of four learning activities with sequential periods is shown in Figure 3.

![Figure 3](image)

**Figure 3.** The average scores of students' applying abilities

Figure 3 shows that for the ability to apply, students have an average score of ≥ 3.1 with a range of scores (3.88-4.12). So online-based physics learning is effective to train to apply ability for students.

3.4. Ability to generating ideas
The ability to generating ideas in online-based physics learning for six modules, each of which consists of four learning activities with sequential periods is as shown in Figure 4.
Figure 4. The average score of a student's ability to generate ideas

Figure 4 shows that for the ability to generate ideas, students have an average score of $\geq 3.1$ with a range of scores (3.73-4.01). So that online-based physics learning is effective to train the ability to generate ideas for students.

3.5. Ability to expressing ideas

The ability of students to expressing online-based physics learning for six physics modules, each of which consists of four learning activities with sequential periods is shown in Figure 5.

Figure 5. The average score of a student's ability to expressing ideas

Figure 5 shows that for the ability to expressing ideas, students have an average score of $\geq 3.1$ with a range of scores (3.75-3.95). So online-based physics learning is effective to train to express ideas ability for students.

3.6. Student responses to online-based physics learning

The effectiveness of online-based physics learning implementation in terms of technical aspects and aspects of learning based on student responses can be shown in Figure 3:

Figure 6. Effectiveness of online-based physics learning based on student responses
Figure 6 shows that the percentage of good responses from students was ≥ 61%. Students' responses to aspects of learning related to the ability to analyze, the ability to assess, the ability to apply, the ability to generate ideas, and the ability to express ideas also correspond to the results obtained from their performance tests. These results indicate that online-based physics learning is effective.

4. Discussion
Online-based physics learning is done through the learning website for teacher training programs. This website has features that contain general guides and specific guidelines for each training module. The website providing guides, leaflets, video phenomena, discussion forums, and assignments that can be accessed through the links provided. Learning created through a website can be useful for practicing critical thinking. To maximize human potential in learning, important factors that must be provided are the environment, information and communication systems [14]. The match between knowledge and digital-based learning can be developed professionalism in a knowledge-based society [15]. Some videos feature physics phenomena that allow students to make observations so that students can think critically. The important thing in managing knowledge is having to consider how to select, store and enter that knowledge [16]. Supporting features on this website allow scenarios, materials, media and learning environments to be well developed.

Online-based physics learning can train students' critical thinking skills with excellent results. All critical thinking elements scores in successive periods show continuity and tend to increase even if small. Each learning activity from each training module is discussed together in a discussion forum before they make a report. They can share information to develop ideas related to topics discussed with critical thinking. Sharing knowledge is needed in managing classroom management [17]. The assessment of tasks allows for an increase in individual knowledge. Also, detailed analysis relevant to individual assignments is useful for analyzing overall task outcomes [18]. The results of previous studies indicate that online-based physics learning can train students' science process skills [19] and [20]. Other research also shows that online-based physics learning can improve learning physics outcomes [21].

Student responses to online-based physics learning are very good. Components that are divided into technical aspects and aspects of learning all get a good response from students. One reason is that the online learning process can be more flexible which can be done anytime, anywhere, and under any conditions [22]. The percentage of effectiveness based on student responses ≥ 61% which indicates that online-based physics learning is effective in training students' critical thinking.

5. Conclusions
The effectiveness of online-based physics learning can be fulfilled from the technical and learning aspects. Online-based physics learning can train critical thinking which consists of analyzing, evaluating, implementing, generating ideas, and expressing ideas. The ability to think critically is assessed in terms of relevance, logic, breadth, and depth of thought. Online-based physics learning gets good responses from students, especially from the technical aspects because it can be operated anytime and anywhere, and from the learning aspect because it encourages students to think critically. The online-based learning process can effectively train students' critical thinking on physics teacher training programs.

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