The dHOTLearn Model to Improve Critical Thinking Skills of Physics Education Program Undergraduate

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The main purpose of this study is to develop a dHOTLearn model based on the physics learning web (PLW), which is intended to improve the critical thinking skills (CTS) of physics education students as well as to optimize the MBKM program at the university level. The research results that the quality dHOTLearn model based on PLW by expert judgments can be used for improving the CTS of physics education program undergraduate. To increase CTS, lecturers prepare structured and rigorous teaching and learning activities utilizing the dHOTLearn paradigm based on PLW. Creating an effective learning environment and learning media to support each action done by lecturers and students at every point in the syntax of the dHOTLearn model based on PLW evaluates the effectiveness of using this learning model. More study can be done to test the feasibility and usefulness of the dHOTLearn model based on PLW for improving the CTS of undergraduate physics education programs.

Keywords: critical thinking skills, educational design research, web-based dHOTLearn, physics learning

INTRODUCTION

The 21st-century learning in the VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) era requires human resources with competence, and the student achievements are directed at learning skills and innovations, including critical thinking skills (CTS) (Mafarja et al., 2022; Wisudariani & Sriasih, 2017), problem-solving skills, creativity (Sandopa & Doyan, 2022), and innovation (Ahmed & Asiksoy, 2021). The speed of technology and information not only affects our lifestyle or the development of education out there, but also affects how to educate students (Troise et al., 2022). So both students and teachers will both need to adapt in the VUCA era (Lee & Moon, 2022).

We need to know that CTS is indispensable for students to be successful in the digital era. Recent research in several countries shows that it is essential for students to obtain and train CTS in universities (Kremenkova et al., 2021), including in Indonesia, especially for physics education students (Satriawan et al., 2020). However, it so challenging to equip these skills during the pandemic due to the unavailability of suitable devices and strategies. Furthermore, digital learning has an essential role during the Covid-19 pandemic. According to the findings of the most recent research, Digital Learning will and is suspected to be a remedy in the world of education during and after the Covid-19 pandemic (McLaren et al., 2022). Therefore, all universities, including the physics education study program, should train CTS through Digital Learning to their students so that they are successful and can compete excellently. One common digital learning approach is to use the web (Zhu & Howell, 2023).

Based on these expectations, Universitas Negeri Surabaya (i.e., Unesa) chose to increase the quality of the learning process and outcomes through suitable (certified) Digital Learning. However, there are problems with developing students' CTS through learning at the university level (Din, 2020), primarily through Digital Learning. Preliminary research findings from the physics education university-level research program (Jatmiko et al., 2018) indicate that students' CTS still needs to be optimal, and lecturers still find it challenging to implement Digital Learning (Lestari et al., 2021; Yan, 2022). Some lecturers even need to learn how to teach CTS effectively (Al-Shaye, 2021).

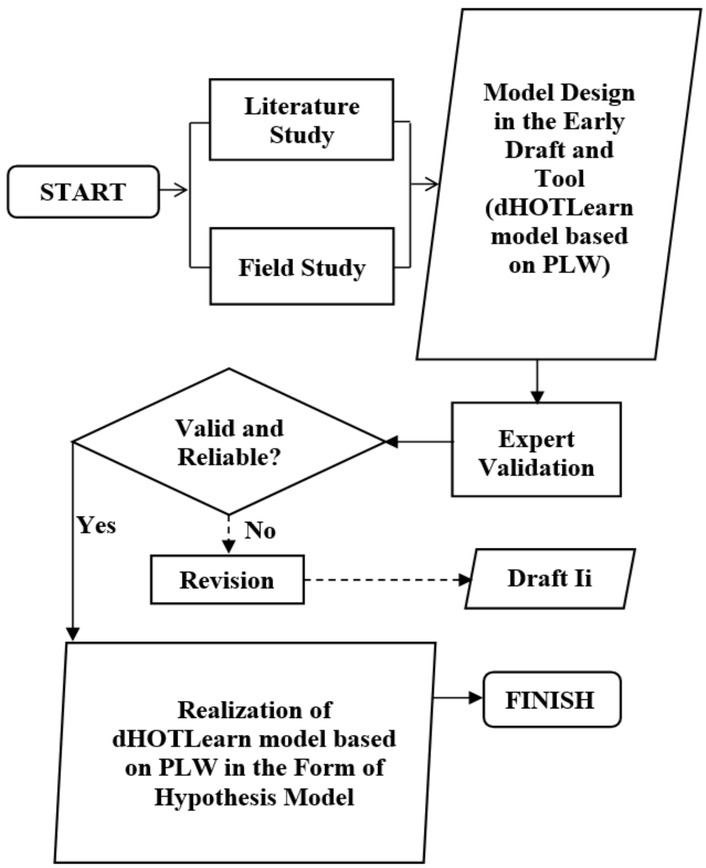
Based on the results of recent research, several digital-based physics learning and e-learning have been used and proven effective to improve CTS, including Problem Based Learning (PBL) (Alandia et al., 2019), virtual classroom (Slisko, 2021), STEM learning (Utami et al., 2021), and web learning (Gherib & Bouhadada, 2021). However, research needs to be specifically designed to improve the CTS for physics education students in optimizing the 21st Century skills at the university level. Because learning activities in higher education are not only develop only from the academic (cognitive) aspect but also develop the skills possessed by students, especially students' critical thinking skills (Li, 2022). In addition, in reality students still have difficulty solving problems related to critical thinking (Al-husban et al., 2022). Therefore, in this research, an innovation of physics learning web-based digital learning is offered, which by design can improve the CTS of physics education students to optimize the 21st Century skills at the university level. The primary goal of this study is to develop a dHOTLearn model based on PLW, which by design can improve the CTS of physics education students at the university level.

METHOD

Educational Design Research (EDR) is used to produce a dHOTLearn model based on PLW, which by design can improve the CTS of physics education students at the university level. Briefly described in Figure 1. EDR is a research design used for education (Boman et al., 2022). EDR is also a range of approaches with the intent to generate new theory, artefacts, and practical models that explain and potentially impact learning in natural settings (Shkatula et al., 2023). By using design research, this research places design as an important part. Design research also aims to develop tools as solutions to educational problems and to advance knowledge about these tools and the process for developing them (Sousa et al., 2022).

In this research design, the first thing the researcher did was identify the problem through literature studies and field studies. The problem in this study is the lack of students' critical thinking skills. At this stage, a search for types of technology that suits the characteristics of students at the university level is carried out. In addition, researchers also analyzed character education handbooks so they could integrate physics learning with character education (Vanderburg et al., 2021). Based on observation and analysis findings were also consulted with practitioners, both lecturers as the main source close to students and several experts in the field of physics. Furthermore, the preparation stage is designing which will be utilized for physics learning. Furthermore, the researchers analyzed so that what was developed was able to meet the needs of students' understanding of the context of learning physics and had practical value (usefulness) that was really needed (Veronica & Huamán, 2022). The design principles that have been developed theoretically are realized in the form of a dHOTLearn model based on PLW product. Then it is validated and evaluated and revised in every aspect until it is suitable for use.

FIGURE 1
THE RESEARCH DEVELOPMENT STAGES OF dHOTLEARN MODEL BASED ON PLW



The validity of the dHOTLearn model is assessed through the contrast of the assessment findings to the criteria of the average validity score, which are: 3.25 < Very valid ≤ 4.00; 2.50 < Valid ≤ 3.25; 1.75 < Less valid ≤ 2.50; 1.00 ≤ Invalid ≤ 1.75. Further study is performed for assessing the resulting GOAL model's quality in terms of the dHOTLearn model's validity and reliability study using single measures interrater coefficient correlation (ICC) and Cronbach's coefficient alpha. ICC was developed based on analysis of variance but in certain cases the results are similar to the alpha coefficient (Rodrigues et al., 2023). Cronbach's alpha calculates the lowest possible limit of a construct's reliability value (Lubiano et al., 2022; Zakariya, 2022).

RESULTS

The developed of dHOTLearn model based on PLW model has been validated by 3 experts. The expert validation carried out is useful to know systematically whether the developed dHOTLearn is in accordance with the objectives or not (Nurhayati et al., 2023). The eligibility data by media experts was obtained through content and construct validity, then media experts provided assessments, suggestions and comments on the available instruments (Bekbayeva et al., 2022). After the media expert has made an assessment of the instruments provided, if there are things that need to be corrected, they need to be revised to improve. The quality assessment results of dHOTLearn model based on PLW model are shown in Table 1.

TABLE 1
THE ARRANGEMENT OF CHANNELS

Component	**Validity and reliability of dHOTLearn model based on PLW**	
Content Validity	**Validity**	**Reliability**
1. Rationale of dHOTLearn model based on PLW Development	Valid	Reliable
2. Knowledge at the cutting edge	Valid	Reliable
3. Model development results monitoring	Valid	Reliable
Construct Validity	**Validity**	**Reliability**
1. Rationale of dHOTLearn model based on PLW	Valid	Reliable
2. Theoretical and empirical backing	Valid	Reliable
3. Syntax	Valid	Reliable
4. Social system	Valid	Reliable
5. Reaction principle	Valid	Reliable
6. Assistance system	Valid	Reliable
7. Educational and accompanist impact	Valid	Reliable

The results revealed that the dHOTLearn model based on PLW has average content validity (valid), construct validity (valid), statistical validity of each aspect (valid), and reliability (reliabel), indicating that the dHOTLearn model based on PLW is of excellent quality. This study suggests that a quality dHOTLearn model based on PLW by expert judgments can be utilized to improve the CTS of undergraduate physics education programs. More study can be done to test the feasibility and usefulness of the dHOTLearn model based on PLW for improving the CTS of undergraduate physics education programs.

DISCUSSION

Each model in learning that is developed certainly has its own uniqueness which is a distinguishing feature between one another. In accordance with the objectives of developing the PLW-based dHOTLearn model, which by design can increase the CTS of physics education students at the university level, there are several characteristics in the developed model. Each method of learning that can be employed in the process of learning has specific characteristics and must adhere to the provisions and needs (Renz & Vogel, 2020). In summary, the characteristics of dHOTLearn model can be explained as follows:

Critical Thinking Skills

Critical thinking has two essential dimensions: the framework of thinking and specific mental work. Furthermore, previous researchers mentioned critical thinking as a cognitive skill in which there are activities of analysis, evaluation, interpretation, and inference in problem-solving. The indications of the CTS include analysis, assessment, interpretation, and conclusion based on the outcomes of preliminary research and literature reviews tests conducted by scientists (Ulu-Aslan & Baş, 2023).

Reinforced by research by (Widiastuti et al., 2022) that critical thinking is the most important part of the purpose of a lesson. Critical thinking entails examining thoughts in a particular direction, sharply separating objects, selecting, and identifying (Muslimin & Abidin, 2023). Before making a decision, students will experience a rational process. The rational process in critical thinking aims to make a decision whether to believe in doing something (Hasruddin et al., 2022). Critical thinking skills can train students' ability to analyze arguments. Understanding in schools, particularly understanding physics, should foster critical thinking skills. Furthermore, critical thinking abilities are vital for empowerment since they can influence students' cognitive learning results (Anghel et al., 2021).

Merdeka Belajar Kampus Merdeka (i.e., MBKM)

Merdeka Belajar Kampus Merdeka (i.e., MBKM) has become a phenomenon and characterizes the product of the Ministry of Education, Culture, Research, and Technology of Indonesia, Nadiem Makarim (Prahani et al., 2020). The idea of eight off-campus learning activities at "Independence Campus" is presented in Figure 2.

FIGURE 2
EIGHT OFF-CAMPUS LEARNING ACTIVITIES OF "INDEPENDENCE CAMPUS"

(Nizam, 2020)

Students are allowed to take courses off campus, and students need to be equipped with competencies related to digital learning abilities (Sihombing et al., 2021). As a result, we must conduct this research to develop a suitable physics learning web-based digital learning to increase physics education students' critical thinking skills to maximize the university's MBKM program, which is packaged as the dHOTLearn model based on PLW.

Theoretical Rationale

It is based on a number of fundamental concepts, including (1) multiple intelligences theory, (2) constructivism learning theory, (3) cognitive learning theory, and (4) multi-representation theory (Mascolo et al., 2022; Wallace & O'Hara, 2017). These theories become the primary basis for developing the dHOTLearn model based on PLW to improve students' CTS through online investigations. These theories serve as the foundation for compiling the steps of the dHOTLearn model, which is based on PLW and consists learning four phases, including: (1) Orientation and problem identification, (2) Investigation, (3) Presentation, (4) Analysis-evaluation and follow-up.

The Targeted Learning Goal

The dHOTLearn model's goal is to improve the CTS of physics education students in order to optimize the MBKM program at the university level. Besides that, it is also expected to generate activity and response and increase student motivation in learning. Reinforced research by (Aldridge & Rowntree, 2022), that there is still a lack of global student motivation towards learning. So it is necessary to increase motivation through learning innovation, in this study using the dHOTLearn Model.

Social System

Lecturers arise, sharpen, and strengthen students' active participation in improving critical thinking skills. Lecturers present motivation and learning objectives, apperception of subject matter, and creating the study groups. Lecturers use the PLW to guide group investigations and construct the tests of CTS and their solutions, presentation of group performance results, evaluation, and reflection and determine the follow-up activity. The interactions among students occur in creating the study groups, distributing logistics, carrying out investigations, presenting group work results, and discussing follow-up actions for the upcoming meeting (Han & Xu, 2022).

Reaction Principle

The reaction principle is the lecturer's reference in responding to student performance results. Lecturers respond to student behavior by (1) exemplary while developing and strengthening CTS, as well as evaluating their achievements; and (2) attempting to implement the idea of fairness by accommodating all student contributions and delivering immediate feedback that follows the set assessment standards.

Support System

The support system is an additional physical and non-physical requirement of the learning model in addition to routine skills, strengths, and abilities. In the learning process, physical requirements take the form of learning demands including: (1) Learning devices and (2) availability of learning needs in the form of Lecturers using the PLW and its supporting systems (such as internet, laptops, cables); and (3) lecturer professionalism in teaching. This support system can support the effectiveness of the application of the tool (Thangamuthu & Tamilvanan, 2022).

Physics Learning Web-Based dHOTLearn Model

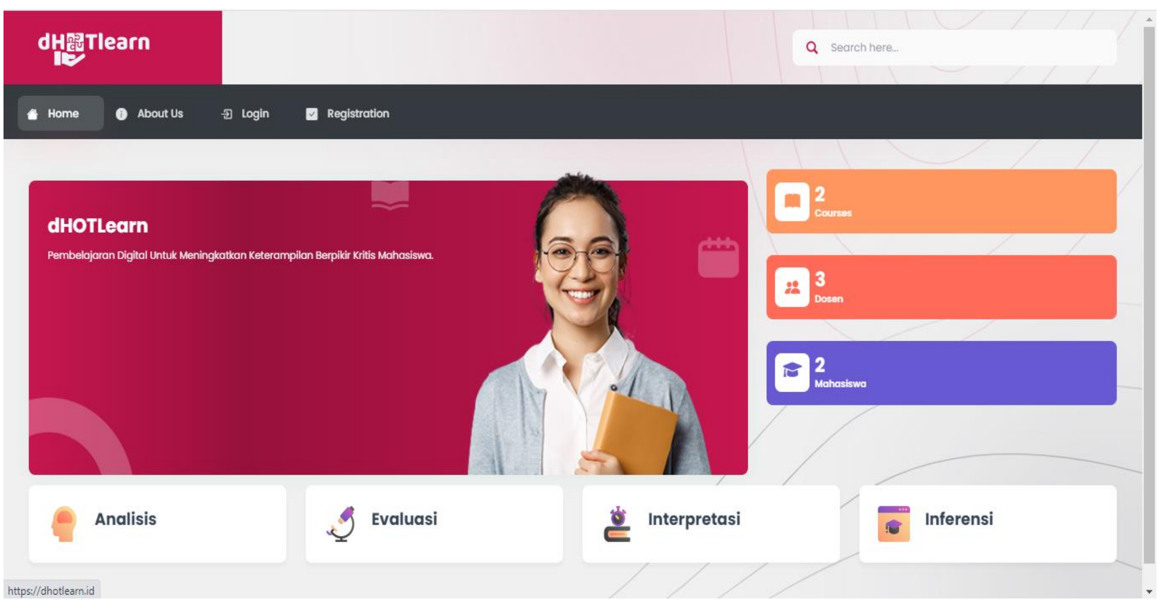
The dHOTLearn methodology is a problem-based digital learning using physics learning web media that was developed specifically for enhancing the CTS of physics learners. The interactive tasks in applying the dHOTLearn model based on PLW are to develop CTS by referring to the syntax presented in Table 2.

TABLE 2
dHOTLEARN MODEL BASED ON PLW

Learning Activity	Indicator
Phase 1: Problem Orientation and Identification PLW is used by lecturers to pique students' interest, focus their attention, and motivate them to participate actively in the learning process. Lecturers use PLW to help students understand the subject and solve mechanical issues that will be debated using various ways that can be tailored to the learning objectives and features of the materials provided.	Analysis
Phase 2: Investigation Lecturers use PLW to assist students in gathering information by completing their worksheets, then guiding students in conducting an investigation step by step, looking for the explanation and solutions to construct their CTS.	Analysis, Evaluation, Interpretation, and Inference
Phase 3: Presentation Lecturers use PLW to aid students in reaching conclusions, discussing the findings of investigations in various formats, and planning, preparing, and presenting their work.	Analysis, Evaluation, Interpretation, and Inference
Phase 4: Analysis, Evaluation, and Follow-up Lecturers utilize PLW to help students analyze and evaluate problem-solving procedures for investigations and processes in many forms of representation, as well as to assess student structured assignments serve as evidence of learning and allow follow-up learning.	Analysis, Evaluation, Interpretation, and Inference

Learning Web is specifically designed to support the implementation of the dHOTLearn model. This app was developed with full support from the College Excellent Basic Research Fund (i.e., PDUPT), DRTPM, Indonesia [2022-2023]. The developed Physics Learning Web can be seen clearly in Figure 3.

FIGURE 3
PHYSICS LEARNING WEB



Learning Environment and Class Management

The success of developing innovation in education can be determined from the learning environment. Apart from that, it is also seen how management works in the classroom (Lubker & Petrusa, 2022). Classroom management is to create a favorable learning environment for students in order to achieve instructional objectives effectively and efficiently (Angelico, 2021; Utama et al., 2022). To increase CTS, lecturers prepare structured and rigorous teaching and learning activities utilizing the dHOTLearn paradigm based on PLW. Creating an effective learning environment and learning media to support each action done by lecturers and students at every point in the syntax of the dHOTLearn model based on PLW evaluates the effectiveness of using this learning model.

The Implications of dHOTLearn Model Development

Many researchers record how digital learning has been successful. In addition to enhancing CTS, the use of digital can enhance the implementation of the learning process, which can increase student absorption and improve the quality of instructional materials (Dickelman, 2022; Souza & Paz, 2020). The dHOTLearn model, which was established through theoretical and empirical research, is projected to have the following practical implications:

1. As a choice of learning models that can be used to improve CTS of physics education students;
2. As a choice of learning models that can be used in the pandemic and endemic era of Covid-19;
3. The availability of learning models that could close the gap the CTS of physics education students;
4. As a resource for developing learning models to improve the CTS of other physics education students;
5. As an alternative solution to optimizing the MBKM program's implementation in higher education.

CONCLUSION

The dHOTLearn approach is a problem-based digital learning with physics learning web media that is specifically created to increase physics education students' critical thinking skills. The dHOTLearn model based on PLW has 4 (four) syntaxes: (1) Orientation and problem identification, (2) Investigation, (3) Presentation, (4) Analysis-evaluation and follow-up. The main objective of the dHOTLearn model based on PLW is to increase the CTS of physics education students in optimizing the MBKM program at the university level. The advantage of this model is that it can facilitate students from other institutions to take part in online learning as a form of the government's MBKM program implementation. The cost efficiency of out-of-island campuses, which need high costs to participate in MKBM, can be reduced with the help of this dHOTLearn model based on PLW. It is also expected to generate activity and response and increase students' learning motivation. This learning model is expected to be an alternative to digital learning to improve the CTS of university-level physics education students. The dHOTLearn model based on PLW is still a hypothetical model (validiy) that needs to be tested for practicality and effectiveness. Therefore, it can carry out further research to prove the feasibility of the study of practicality and effectiveness tests, especially in the learning activities to improve CTS of physics education students.

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