Developing d-Worksheets by applying 7 steps of problem-based-learning to enrich students’ critical thinking skills

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Abstract. Critical thinking is important for students in developing critical thinking skills. Critical thinking is able to determine actions related to a wide variety of information. The benefit of critical thinking is to prevent students from the massive influence of hoax news that is widely circulating today. Critical thinking also plays a key role in making decisions. This ability can be developed in lectures through the right method. To make it more optimal, learning can obviously be managed to use good quality worksheets. The objective of this study is to design a draft of digital worksheets (d-Worksheets) based on the Problem-Based-Learning (PBL) that is valid for improving students' critical thinking skills. The research procedure used Borg & Gall’s method classified into four steps, namely 1) Analysis of products to be developed, 2) Initial product development 3) Expert validation and revision 4) Small-scale field trials and product revisions. The research results show that the form of d-Worksheets draft using Adobe Flash is compatible with laptops or computers. The draft of d-Worksheets contains information, images, and interactive videos. The draft was designed for the health science lecture on the health topic of a human circulation system, implementing seven steps of PBL, and referring to expected critical thinking skills. Thus, the draft of d-Worksheets is developed to meet the feasibility according to experts, but it requires further revisions. The draft can increase critical thinking skills according to the experts and students’ experiences.

1. Introduction
Critical thinking is an important aspect in developing students’ learning [1]. The growing concern is that critical thinking is one of the aims of higher education [2]. Graduates are required to solve job-related problems including critical thinking, innovation, soft skills or communication competence [3-6]. In addition, critical thinking is one of the most important skills in life [7]. Some graduate users think that graduates are still lack of critical thinking skills. For that reason, universities need to continually improve the quality of learning [8]. The quality of learning can improved using innovative methods, media, modules, and worksheets that support learning considerably.

In-class observations show students’ weak critical thinking skills. In some circumstances, students tend to search for references from the search machine and download them, but they do not analyze the accuracy of data in advance. Students are also lack of conveying ideas and objections toward discussion activities. Furthermore, they are obviously unenthusiastic about responding to lecturers’ questions. This
affects the success of lectures. The problem of low critical thinking not only occurs in class during observations, but also in other universities [9]. This situation turns out to happen to students in several Asian countries [10].

Critical thinking is beneficial for students to improve learning abilities because, in certain situations, it can train students to identify, clarify and focus on problems, analyze and draw conclusions, use logical reasoning and check the accuracy of sources [11]. Critical thinking is basically a series of analytical activities to solve a problem [12]. Through critical thinking, a person is able to clarify, think deeply, and become a problem solver in social life [13]. Critical thinking is mainly concerned with the decision making process rationally or assessing conclusions [14-15]. In this sense, one of the benefits of critical thinking is to help students to solve problems both in learning and life contexts.

The number of hoax news currently circulates through news on social media resulting in negative effects of hate speech, interaction violation and defamed reputation. High-level critical thinking skills determine critical attitudes to respond to the truth of the news and how to take a stance. The negative impact of the hoax news is immensely huge and one of them is to ignite the disunity of the nation.

Students' critical thinking skills pave the way for realizing problem-based learning models commonly called problem-based learning (PBL). Through this learning model, lecturers encourage students to solve problems involving group work and solutions to problems through high-level thinking processes [16-18], the development of critical thinking, leadership and group work skills [19-20]. These reasons are the starting points for researchers to choose the problem-based learning as a solution to improve students' critical thinking skills.

Quality learning processes require supporting media to help the processes of transferring information from lecturers to students. Student worksheets are used to meet learning needs or be used to achieve goals set by lecturers or researchers [21]. As the problem-based learning is a learning model that optimizes students' thinking skills, researchers assume that a sheet of student’s activities is likely to achieve learning goals.

This research aims to develop computer-based worksheets or digital worksheets (d-Worksheets) by applying the problem-based learning to improve critical thinking skills. The developed worksheet is paperless, multimedia-based, and interactive using the Adobe Flash software. This worksheet can be installed in a laptop or PC, and its specific characteristics deal with the following seven steps in terms of the problem-based learning model. Each stage of the worksheets includes critical thinking skills that can be developed further.

The seven steps in the problem-based learning model include 1) clarifying unclear terms and concepts, 2) formulating the problem, 3) analyzing the problem 4) organizing and analyzing ideas deeply, 5) formulating learning objectives, 6) extracting information from various sources, and 7) synthesizing and testing the new information [22]. The critical thinking will be developed 1) to determine the credibility of the information source, 2) to differentiate relevant things from the irrelevant ones, 3) to distinguish facts from assessments, 4) to describe and evaluate unspoken opinions, 5) to seek biases, 6) to identify points of view, and 7) to evaluate evidence offered to support recognition [23].

For researchers, this research can train to develop quality worksheets. For students, it can support learning processes in the framework of a problem-based learning model. Theoretical benefits are in the form of information about how worksheet development processes can be applied using the seven steps of the problem-based learning to improve students' critical thinking skills.

2. Methods

This research procedures adapted from Borg & Gall [24], [25] involving five steps, namely (1) The analysis of products to develop, (2) The initial product development, (3) The expert validation and revision, (4) Small-scale field trials and revisions products, and (5) Large-scale field trials and final products.

Of the five steps, the researchers had reached steps 1 to 4. The first step deals with theoretical studies and empirical studies on subjects. The subjects were taken by health sciences courses that contain topics
on efforts to maintain the health of the human body. Researchers assume that the topics are suitably used in the problem-based learning model. Many problems can be related to the human health. In addition, the references can be searched for easily. The topic of human health is of interest because it encourages students stay healthy in everyday life.

The second step is the initial product development. The result is a draft of d-Worksheets that is adapted to the problem-based learning syntax. The d-Worksheets development follows the steps developed by Sutopo [24] consisting of concept stages: developing concepts and a problem identification, formulating objectives, learning needs analysis, character analysis of users, planning and designing the d-Worksheets software. The stage design includes the designing software in relation to physical, functional, and logic designs. In what follows, developing a flow chart is set to visualize product workflows from the beginning to the end. The stage of collecting materials covers the collection of lecture materials needed to make products. The stage of assembly is composed of compiling the text of lecture materials in each frame referred to as screen mapping. The characters of d-Worksheets are developed based on the seven steps of problem-based learning, and each step shows a wide variety of critical thinking skills worth developing. The hope is that critical thinking can help students increase critical thinking skills.

The third step is to carry out an expert’s review that involves experts in related fields in accordance with the products being developed. The draft of d-Worksheets is delivered to experts for the purpose of validation and more qualified inputs or feedbacks involving experts on the learning products development, experts on the topics under discussion, and linguists. This expert’s review was used as a reference in revising the draft of d-Worksheets. The expert’s inputs relate to the correctness of concepts, the quality of design, packaging, ease of operation, and how the draft of d-Worksheets improves students’ critical thinking skills. The results of this stage are revised drafts of d-Worksheets.

The fourth step is mainly concerned with trials in small groups involving students through focus group discussions. At this stage, the draft of d-Worksheets was re-piloted by involving small-scale users. Students attempted to use d-Worksheets and were asked to give inputs or suggestions in terms of the language level of difficulties, design or appearance, ease of use, and impression after using. The result of this stage is the draft of d-Worksheets that has been revised pertaining to the users’ inputs. The trial stages can be seen in the following table.

| Trial Stages          | Number of samples | Characteristics of samples | Sampling techniques | Trial results                   |
|-----------------------|-------------------|----------------------------|---------------------|--------------------------------|
| Expert’s Test         | 3-6               | Experts in the learning products development, IT-based learning media experts, linguists | Purposive           | Qualitative, preliminary draft of products |
| Small-scale group     | 4-5               | Product user (students)    | Random              | The suitability of products with users |

Referring to the information in Table 1, the experts’ sampling is a purposive technique. Researchers chose experts in the field of learning products development, IT-based media learning experts, and linguists. Students were selected in accordance with the products feasibility trials conducted randomly.

The method has similarities with the 4D method [26] that consists of dimensions to define, design, develop, and disseminate. When examined, a number of processes carried out by researchers passed defining, designing, and developing stages. The next step needs to deal with the dissemination.

The technique of collecting data used a questionnaire, and it aimed to make an assessment according to experts and student users. The assessment used scores with a range of 1 to 5 scores for each item. The score results were made on average to determine the products feasibility, and the data were analyzed descriptively and qualitatively to draw conclusions.

Table 1. The Trial Stages of d-Worksheets
3. Results and Discussion

This development research used Borg & Gall’s modification states. The first stage is carried out through theoretical studies and empirical studies of subjects. The subjects were taken from health sciences courses. The materials in the health sciences lecture are related to human health and environment. Some topics of discussions include general health, principles of nutrition, health of the digestive system, circulation, breathing, excretion, reproduction, coordination, exercise, public health, infectious diseases and non-communicable diseases.

From these topics, researchers took three topics of students’ choices, namely digestive system health, respiratory system health, and circulation system health. The selection of this material was taken by considering the material levels of difficulties, the number of problems under discussion, and various problems in terms of real life topics that can train the critical thinking. The researchers assumed that the theme was suitable for the problem-based learning model. In the end, the researchers chose a topic (as the main topic) for the development of d-Worksheets, namely the health of the circulatory system. This selection takes into account the interrelationships between topics whereas the circulatory system is closely connected to the digestive system and respiratory system. To study the health of the circulatory system, students need to explore the digestive system and respiratory system.

Empirical studies were conducted by reviewing students’ characteristics, curricula and learning processes. In addition, the researchers took references from books to get insight into preparing the d-Worksheets development and how to improve critical thinking skills through teaching materials. In the KKNI (the National Qualification Framework)-based curriculum, a generic level of six descriptions is important for students to utilize science and technology in the field of expertise and they are able to adapt to the situation in solving problems. The d-Worksheets development also refers to such a curriculum.

The second step is developing the initial product in the form of the d-Worksheets draft. The products are adjusted to the problem-based learning steps. In the research method, the development of d-Worksheets follows the steps developed by Sutopo [24] consisting of concept stages, namely developing concepts and problem identification, formulating goals, analyzing learning needs, analyzing users’ characters, planning and compiling the d-Worksheets software.

The design stage aims to design the software that includes physical, functional, and logic designs followed by developing a flow chart to visualize product workflows from the beginning to the end. The software is designed to make these d-Worksheets using Microsoft Office PowerPoint and Adobe Flash Professional CS6. The Microsoft Office PowerPoint is used to create designs and animations that will be converted with Adobe Flash Professional CS6, so that they can be interactive and easy to pack. This software is also used to make evaluations or practice questions that use judgment automatically. Thus, the truth of the answer can immediately be known. The advantages of Adobe Flash Professional CS6 include dimensions to create multimedia worksheets, designs according to the needs of the manufacturer, and the worksheets can be operated on a laptop or PC with low specifications.

Stages of collecting materials include the collection of lecture materials that will be used to make products. At this stage, the material collections are carried out with reference studies from various sources. The references can be books, encyclopedias, journals, and websites. The stages of assembly are set to compile scripts for lecture materials involving each frame commonly called screen mapping. This stage is carried out to get a design material connected to the health of the circulatory system. The researchers used several sources from books to make this material.

The d-Worksheets contain applications along with a menu button to run them. Each menu button can be clicked and consequently it will go to the destination menu. The procedure section contains procedures for using the d-Worksheets. The step of the activity contains the activity procedure in accordance with the problem-based learning syntax. The material menu contains materials about the health of the circulatory system. While the evaluation menu contains interactive exercises, so that they can show obtained results.
The third stage is the review of experts. The experts involved in the development of this product consist of design and material experts, computer-based learning media experts, and language experts. Expert designers are chosen leaders who understand the problem-based learning and critical thinking, and understand how to develop media, modules, or d-Worksheets. The selected media experts have the expertise in the field of planning and developing computer-based learning media. Selected linguists have the expertise in the field of language or proficiency in writing languages. By involving these three experts, it is hoped that the result of development can meet the conceptual aspects of the concept, the correctness of language, and the suitability and appearance of the packaging.

This d-Worksheets development process involves discussions in accordance with material experts and designers. Some instructions designed by the expert deal with the problem-based learning model consisting of seven steps of activities. At first, the researchers developed d-Worksheets along with five steps as mentioned in the previous studies. Of these seven activities, three lectures are planned. Each step of activities in the lectures refers to the expected critical thinking. The seven stages of problem-based learning are described in the table below.

| Lectures | Stages & Purposes | Activities |
|----------|------------------|------------|
| I        | Clarifying unclear terms and concepts. | 1. Students form heterogeneous groups of 3-4 members.  
2. Students study materials on the circulatory system in the body  
3. Students conduct reference studies on the cholesterol  
4. Students analyze the concepts of circulatory system and cholesterol in the body |
|          | Formulate the problem: The phenomenon in the problem requires an explanation of relationships between the phenomena. Therefore, it needs a further clarification. | Students discuss problems in groups. An in-depth analysis is absolutely done. |
|          | Analyze problems | Each member conveys the knowledge related to existing problems. |
|          | Organize ideas systematically | Students discuss ideas deeply. Parts are closely related to each other. Even each group supports contradictory ideas using an in-depth analysis. |
|          | Formulate learning objectives. | The group formulates learning objectives because they have already known parts that are still lacking and unclear. Learning objectives will be associated with the analysis of problems. This basis of idea will be stated in a report. There is an assignment for each group member. |
Table 2. shows seven problem-based learning steps. The number of lectures were held three times. The first lecture was held in the classroom (IN), the second lecture was held outside the classroom (ON), and the third lecture was re-implemented in the classroom (IN). Outputs or learning outcomes are in the form of scientific reports and PowerPoint presentations. Each problem-based learning step is associated with the expected critical level, as elaborated in Table 3 below.

**Table 3.** The Syntax Relationship between Problem-based reading and Critical Thinking

| Learning Steps/Activities | Critical thinking |
|---------------------------|-------------------|
| **Step 1. Clarify unclear terms and concepts.** | 1. Determine the credibility of a source  |
|                          | 2. Distinguish between relevant and irrelevant concepts  |
|                          | 3. Identify existing biases  |
| **Step 2. Formulate problems** | 1. Distinguish between relevant and irrelevant problems  |
|                          | 2. Identify existing biases  |
|                          | 3. Differentiate facts from judgment  |
|                          | 4. Identify points of view  |
| **Step 3. Analyze problems** | 1. Distinguish between relevant and irrelevant problems  |
|                          | 2. Distinguishing facts from judgment  |
|                          | 3. Identify and evaluate unspoken assumptions  |
| **Step 4. Organize and analyze ideas systematically and deeply** | 1. Distinguish between relevant and irrelevant ideas  |
|                          | 2. Identify existing biases  |
|                          | 3. Differentiate facts from judgment  |
|                          | 4. Identify points of view  |
|                          | 5. Identify and evaluate unspoken assumptions  |
|                          | 6. Evaluate the evidence offered to support recognitions  |
| **Step 5. Formulate learning objectives** | 1. Determine the credibility of a source  |
|                          | 2. Distinguish between relevant and irrelevant objectives  |
|                          | 3. Identify existing biases  |
| **Step 6. Look for additional information from other sources** | 1. Determine the credibility of a source  |
|                          | 2. Distinguish between relevant and irrelevant sources  |
Learning Steps/Activities | Critical thinking
--- | ---
Step 7. Synthesize and test the new information. | 1. Determine the credibility of a source
2. Distinguish between relevant and irrelevant information
3. Identify existing biases
4. Differentiate facts from judgment
5. Identify points of view
6. Identify and evaluate unspoken assumptions
7. Evaluate the evidence offered to support recognitions

As Table 3 evidences, each problem-based learning step associated with critical thinking skills can be improved. The total indicators of critical thinking have seven types. This refers to Beyer’s notion [23]. The seven indicators include: 1) determining credibility from a source, 2) distinguish between relevant and irrelevant things, 3) distinguish facts from assessment, 4) describe and evaluate unspoken opinions, 5) look for biases, 6) identify points of view of things, and 7) perform the evaluation of evidence offered to support recognitions.

Material and design experts provide inputs on the draft of d-Worksheets. These inputs include 1) the procedure part, seven displayed problem-based learning steps, 2) the procedure section is necessary to display expected critical thinking indicators, 3) three columns in the procedure section cover syntax, command/procedure, and expected critical thinking, 4) criteria for lectures are displayed as IN or ON, and 5) the problem-based learning and critical thinking in the draft of d-Worksheets. From this input, researchers change the appearance of products being developed.

Before the draft of d-Worksheets are consulted, researchers assume that the problem-based learning syntax and critical thinking are not displayed because the d-Worksheets are closed. However, directives from experts are displayed because they will clarify the purpose of the lesson to achieve. For this reason, the researchers made a product revision. Researchers make improvements as directed by experts in all parts of the procedure menu.

Material and design experts provide assessment scores by filling out questionnaires. The assessment criteria include 1) very low, 2) low, 3) sufficient, 4) good, and 5) very good. The assessment factors cover aspects of content eligibility and the feasibility of presentation. Scores have a range of 3 to 5 along with an average score of 3.73 (more than enough). Material and design experts also draw a conclusion that d-Worksheets are feasible to use, but they need further revisions.

The researchers consulted experts on the development of computer or IT-based learning media. The results of discussions prove that several inputs were obtained, namely 1) using the visual icon, the pixel was repaired, so that it would not break, 2) using the text format, and justifying it well, 3) the contrast between the background, icon, menu, and writing, 4) ensuring that the export application can be compatible with any PC devices, and 5) the users are given an alternative to choose materials (tentative in nature).

The learning media input from the expert was used as materials for revising the draft of d-Worksheets. Of the five input points, the researchers took four of them ranging from the first point to the fourth point. The fifth point is an alternative in nature. The problem-based learning emphasizes the search for results of supporting data by the students themselves. In other words, active students try to find out sources of information to support learning processes.

Linguists provide general comments, namely 1) the use of Indonesian in the d-Worksheets is communicative. The choice of words is adjusted to encourage students to think critically, and 2) few
disadvantages or weaknesses need to be corrected include the use of foreign terms that has not been standardized.

Inputs by linguists are used as revised materials in terms of language. The linguists’ scores range from 3 and 5 with an average score of 4.00 (good). Linguists conclude that the draft of d-Worksheets is appropriate to use in terms of language and require improvements (revisions).

The stage of products development involves the Focus Group Discussion (FGD). The researchers involved 5 students as users to try out the draft of d-Worksheets and provide expected inputs or suggestions. The suggestions from students are summarized, such as 1) the size of writing needs should be enlarged to reduce the blank space on the screen, 2) the music or sound may vary, so that it is not monotonous, 3) the color of the writing needs to be improved with the more comfortable background, 4) the layout of the writing can be designed more centered, 5) the background color can be different, so that it is not monotonous, 6) well-equipped supporting videos, 7) a clear caption required in the image, and 8) evaluation questions may vary based on short entries.

The users’ inputs are used as materials for products revisions. The researchers conclude that the draft of d-Worksheets needs revisions in terms of appearance to make it more attractive and pleasing to the eye. In addition, it will also provide an additional menu, that is, a supporting video that contains the circulatory system disorders including atherosclerosis, heart attacks and strokes. The video is connected to the website www.youtube.com. For the sake of evaluation, researchers plan to revise questions that refer to the ability to think critically.

The inputs of experts and students are used for products revisions to make them better and easier to use. Temporary results in the form of the d-Worksheets draft will be re-tested on a larger scale depending on revised and obtained final products. Although the draft up to this stage is incomplete yet, the products submitted to the Indonesian Intellectual Property Rights in the Ministry of Law and Human Rights of the Republic of Indonesia (Kemenkumham RI) were declared to have passed.

4. Conclusion
The problem-based learning model of the d-Worksheets development can increase students’ critical thinking skills and it has produced drafts or prototypes. The draft of d-Worksheets is feasible to use according to experts and requires better revisions. The draft of d-Worksheets can encourage students' critical thinking skills based on the experts’ opinions.

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