Improving students' communication skills and critical thinking ability with ICT-oriented problem-based learning and the assessment instruments with HOTS criteria on the immune system material

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Abstract. This study aims to facilitate high school students' communication skills and critical thinking ability with ICT-oriented problem-based online learning and assessment instrument with HOTS criteria. This research approach is pre-experimental, with the one group pre-test-post-test design. This study involved 36 students of XI MIPA 4 and biology teacher at a high school in Jepara, Indonesia. The number of samples determined using the purposive sampling technique. The data collected includes data on students' critical thinking skills, students' communication skills, implementation of the learning process, teacher and student response data regarding teaching materials, and the learning process. Data of critical thinking skills were analyzed using the n-gain test. Other data were analyzed descriptively qualitatively. The results showed that students achieved a critical thinking skill level with N-Gain 0.31 (medium category) and communication skills 83.00 (very good category). The average score of the implementation of the learning process is in a good category, meaning that all syntax is carried out well. Teachers and students consider that ICT-based teaching materials are quite practical to use. According to them, the learning process is in a good category (positive). Conclusion: students' critical thinking skills and communication skills can be facilitated through online learning with ICT-oriented PBL approach teaching materials and ICT-oriented HOTS assessment instruments.

1. Introduction

Student's Critical thinking skills and communication ability are important to develop in the globalization era [1]. Critical thinking is one of the competencies in higher-order thinking [2]. Communication is a process of exchanging information between two sources, which is an important component in the teaching and learning process [3]. Learning activities in the 2013 curriculum include communication aspects in the learning stages to foster honesty, thoroughness, tolerance, thinking systematically, expressing opinions, and developing good and correct language skills [4]. Thus, it is clear that students' critical thinking ability and communication skills need to be trained through the learning process. The learning process needs to be facilitated with teaching materials [5]. The teaching materials used in this study were supplementary teaching materials about the immune system, which has a PBL approach and is ICT-oriented.

Communication skills indicators [6] include information retrieval, scientific reading and writing, listening and observing, data representation, and knowledge presentation. In this study, the communication skills were measured limitedly, that is, in the written communication skills [6] with

several indicators of communication skills, namely 1) information retrieval, 2) observation/observing, and 3) knowledge presentation. Written communication skills are assessed using non-test instruments [7]. In this study, data were obtained from assessing the quality of the student's scientific reports and posters.

It has been stated above that critical thinking ability, and communication skills need to be trained through the learning process. During a pandemic situation, Indonesia's learning activity is held online, using ICT with the various smartphone applications. This situation forces educators to carry out the various innovations, to carry out a learning process appropriately with the current condition. The use of smartphone applications in the learning process is proven to help students think critically [8]. The use of ICT (ICT) helps teachers carry out a more practical learning process [9]. Teaching materials with the PBL approach is proven to significantly improve students' critical thinking ability [10]. The PBL approach is useful for improving the student's critical thinking ability [11]. The PBL approach/model has a five steps syntax that is (1) organizing students in the problems / orienting students to the problems, (2) organizing the students to learn, (3) helping the student in the investigation process, developing and presenting the study results, (5) to analyzing and evaluating the problem-solving process.

Student's critical thinking and communication skills are the abilities that must be supported by high order thinking skills (HOTS). HOTS needs to be measured using an instrument that contains the questions with HOTS criteria [12]. Critical thinking is the ability to use a reason to offer evidence by analyzing and evaluating a reason to solve a problem [13]. The higher-order thinking skills include the ability to solve problems (problem-solving), critical thinking ability, creative thinking, reasoning skills, and decision-making skills [4]. The HOTS deals with analyzing, evaluating, and creating activities. Critical thinking skills and communication skills must be supported by high-order thinking skills (HOTS). HOTS needs to be measured using a measurement instrument that contains questions with HOTS criteria [14]

In this research, the HOTS assessment instrument was developed with 8 sub-indicators of 3 indicators of critical thinking skills according to Facione [15], namely interpretation, analysis, explanation, and evaluation [15]. Interpretation has 3 sub-indicators, that are grouping, describing the meaning/meaning, clarifying the meaning/meaning, or making it clear. Analysis has 3 sub-indicators, namely testing ideas, recognizing arguments, and analyzing arguments. The explanation has 6 sub-indicators, namely describing methods and results or stating results, underlining procedures or supporting procedures, proposing and defending well, and presenting well. Evaluation has some sub-indicators, namely assessing the credibility of the question, assessing the quality made, and making and determining the considerations' results.

In this study, an instrument for assessing critical thinking skills with HOTS criteria was developed using the Quizizz application. Quizizz is a web tool for creating interactive quizzes, which supports the learning process in class [16]. Lestari [16] stated that using technology in learning (especially in e-learning) can positively increase students' knowledge. Quizizz was chosen to be used in this study because it can make students excited to understand the lesson (both in class and at home, through independent study) to complete tests more independently [17].

Methods

This research is pre-experimental, with the one group pre-test-post-test design. The research was conducted by implementing biology learning (with the immune system's topic), using special teaching materials. The specific teaching materials referred to the ICT-oriented teaching materials, whose has contents are in the order of problem-based learning syntax (PBL). This teaching material is specially prepared, equipped with a description of basic competencies, competency indicators, learning objectives, and concept maps about the immune system's topic. This teaching material supplement is also equipped with a menu of "the group activity" and "the individual activity," which contains the student's discussion sheets (worksheets), both in groups and individually. This teaching material supplement is also equipped with a menu, "Bio Info," which contains additional valuable information for expanding the students' knowledge. Those teaching material supplement id developed by Sella Ingesti *et al.*, 2020, unpublished/in the process to publish)

This study involved 36 students of XI MIPA 4 and biology teacher at a high school in Jepara, Indonesia. The number of samples determined using the purposive sampling technique. The data collected included data on the critical thinking ability, the implementation of the learning process, the student communication skills, and the teacher and student response regarding the teaching materials and the learning process. Data analysis: data of the critical thinking ability were analyzed using the n-gain test. The other data were analyzed descriptively qualitatively. The critical thinking ability data in this study were measured using instruments developed regarding Facione [15].

The instrument for measuring critical thinking ability (with HOTS criteria) used in this study is an instrument that uses the Quizizz application with 30 items (were developed by Lutfi Rahma Adiani *et al.*, in 2020, unpublished/in the process to publish). Each item in those instruments consisted of a stimulus, subject matter, and 5 alternative answer choices with one answer key. This instrument has empirical reliability of 0.68 and internal consistency of 0.83, moderate difficulty level, and good distinguishing power.

The data on the students' written communication skills were obtained by measuring the quality of posters and scientific reports written by students [6]. In this study, the quality of the scientific reports and posters written by students was determined as an indicator of their written communication skills. The student's written communication skills include several sub-skills, namely sub-skills in information retrieval, observation, and knowledge presentation [6]. Based on those indicators of written communication skills, a product assessment instrument was developed. The products assessed are scientific reports and posters written by students. The aspects of the scientific report that are assessed include cover, problem formulation, objectives, general theory, tools and materials, discussion, conclusions, suggestions, and references. The aspects of the poster assessed include content/text, poster design, image quality, and message delivery.

The learning process is carried out by following the PBL syntax. The PBL model has a syntax that is divided into five steps [11], namely (1) organizing the students into the problems / orienting students to the problems, (2) organizing the students to learn, (3) helping students to carry out the investigative pro[10]s, develop and present the results, (4) analyze and evaluate the problem-solving process.

This research procedure consists of 3 stages, namely the preparation, implementation, and data analysis stages. The preparation stage includes making ICT-oriented PBL teaching materials (on the immune system material), making instruments for assessing critical thinking skills and [8]mmunication skills, and other instruments. The research implementation stage included giving a pre-test to measure students' critical thinking skills. The following process is gi[12]g a treatment using ICT-oriented PBL-based teaching materials, which contain several indicators to improve students' critical thinking and communication skills. The learning process's implementation stage includes giving questionnaires through the WA-app group chat, giving post-test (using HOTS assessment with Quizizz application), and [5]easuring written communication skills using non-test instruments. The next stage is data analysis: the critical thinking skills data were analyzed using the N-gain test, while the other data were analyzed descriptively qualitatively.

[4]

3. Results and discussion

The results of research discussed in this section include 2 things, namely a) implementation of the learning process w[2]h ICT-oriented problem-based learning (using ICT-Oriented PBL Approach Teaching Material) and the assessment instruments with HOTS criteria, b) the students' critical thinking ability and the students' writing communication skills. This section also explains how the teaching material supplements can improve the dependent variable, especially on the immune system material, which students learn during the research process. At the end of this section was presented the teacher and student response data regarding teaching materials (the immune system material) and the learning process held.

3.1. The learning implementation / execution using the ICT-oriented PBL [11] teaching materials.

The implementation of the learning pro[8]ss using the ICT-oriented PBL be described as follows. The activity begins with giving an online pre-test to measure the level of the student's critical thinking ability

at the initial state. Then, the learning activities are carried out according to the PBL syntax, which uses learning supplements, carrying out learning according to the PBL syntax. In the learning process, a special teaching material supplement is used, equipped with a concept map of the immune system material, four discussion activities, and a presentation of material divided into 2 sub-chapters.

Based on the observations made by three observers, information was obtained that the full syntax was carried out well. The learning process's implementation is closely related to the content of the teaching material supplements used in this study. A description of the intended teaching material supplement and the types of student activities that students carried out during the learning process are described as follows.

The components contained in the supplement teaching materials about the immune system are (1) destination, (2) concept maps, (3) discussion (four activities), description of the immune system material (two sub-chapter). The destination component is described as the formulation of learning objectives, contains indicators of critical thinking, according to Facione [15]. In this section, student activities are observed, and understand learning objectives. The competency aspects involved are analysis and self-regulation aspects of critical thinking skills [15]). The concept maps component is described concept maps to make it easier for students to understand the immune system material. In this section, student activities are reading the pictures. After reading the pictures, students are trained to describe several layers of the body's defense system. The competency aspects involved are interpretation, analysis, and explanation. Those are the aspects of critical thinking skills [15].

The discussion-1 component is presented issues regarding immunization. In this section, students watched a video about the immune system innate and adaptive. The competency aspects involved are interpretation, analysis, explanation, and evaluation. Those are the aspects of critical thinking skills [15]. The discussion-2 component presents the cases related to the problem of an active and passive immune system. In this section, student activities are looking for information from various relevant sources and the importance of community participation in the immunization program. The competency aspects involved are interpretation, analysis, explanation, evaluation (aspects of critical thinking skills), and information retrieval (aspects of written communication skills). The discussion-3 component is presented assignments for groups of students, searches for information from various relevant sources, and the importance of community participation in the immunization program. In this section, student activities are Making a written report (scientific reports and posters). The competency aspects involved are interpretation, analysis, explanation, evaluation (aspects of critical thinking skills), and retrieval of information, observation, and knowledge presentation. Those are aspects of written communication skills [6-7]. The discussion-4 component is presenting an example of immune disease, namely HIV & AIDS. In this section, student activities are Students carry out the analytical activities (identify arguments) through the literature studies on the process of infection with HIV until AIDS develops, how AIDS is transmitted, and how to prevent it. The competency aspects involved are interpretation, analysis, explanation, and evaluation (aspects of critical thinking skills), and information retrieval, and the presentation of knowledge (aspects of written communication skills [6-7]

The sub-chapter-1 of the description of the immune system material component contains (1) the material related to the body's defense mechanisms, the layers of the body's defense (presented in the form of pictures), (2) an explanation of the aspects contained in the activity of observing the structure of B cells and T cells. In this section, student activities are (1) carry out the interpretation activities that involve the competence of describing the meaning and categorizing information, and (2) are trained to be able to describe the results of the process of observing images, then they are assigned to describe the structural differences between B and T cells. The competency aspects involved are interpretation, analysis, explanation, and evaluation (aspects of critical thinking skills [15]), information retrieval, observation, presentation of knowledge (aspects of written communication skills [6-7]. The sub-chapter-2 of the description of the immune system's material components contains material on immune disorders, discussing immune diseases, and presents the material about the Covid-19 pandemic outbreak. In this section, student activities were assigned to dig deeper information about the outbreak, then relate it to the immune system material. Student's experience facilitating to do "self-regulation." The competency

aspects involved are and evaluate video content and information retrieval, and presentation of knowledge (aspects of written communication skills).

Based on the description of the research results above, it can be stated that the teaching material supplements used in this study have been equipped with various valuable activities to facilitate the students to develop their competence in the interpretation, analysis, inference, evaluation, explanation, and self-regulation. These competencies are competencies that underlie a person to think at a high level, one of which is critical thinking skills.

The improvement of the critical thinking skills that occur during the learning process using specially packaged teaching material supplements can be explained as follows. Students carried out various activities during the implementation of the learning process, including observing pictures about several layers of the body's defense system, describing and analyzing those pictures. Students were also assigned to watch videos about immune innate and adaptive systems. During those learning process, students are trained to interpret and analyse the contents of the video, formulate/express a statement (explanation), and evaluate video content. Activities such as interpret, analyse, formulate an explanation, and evaluation are an aspects of critical thinking skills [15]. Activities categorizing the characteristics of the innate and adaptive immune system, reviewing material about the immune system through videos and other activities are useful for practicing higher order thinking skills. This is in accordance with the findings of Isnaeni *et al.* [18]. According to her, the good communication skills and the critical thinking skills of students can be an indicator of the higher-order thinking skills. Communication skills, critical thinking are part of the 21st century skills that need to be mastered by students [19-21].

From the description of the research results above, it can be seen that in the learning process which using the teaching material supplements with an ICT-oriented PBL approach, students are facilitated to make an explanation (describe and explain the differences between B cell structures and T cell structures accompanied by appropriate reasons). In these activities, students are also assigned to make the written reports (scientific reports and posters). This activity shows that in this learning process students are trained to carry out the written communication. In this study, the measurement of the written communication skills in students was carried out by assessing the quality of the product (by product assessment). The products in this research are the scientific reports and the posters.

From the description of the research results above, also obtained information that the learning process with the teaching material supplements that used in this study is useful for practicing the oral communication skills. When students observe pictures about the structure of B cells and T cells, then they are assigned to describe the structural differences between B and T cells, they are trained for describing the meaning and categorizing information. At that time, students were also assigned to re-discover information, observe, and present some knowledge. All those activities are aspects of communication skills, especially in written communication [6-7]. It can be emphasized that the use of this special teaching material supplement in learning is useful for improving communication skills, especially in written communication. This means that students who learn to use supplementary teaching materials about the immune system, their written communication skills become trained. The continuous training can improve their communication skills, especially in written communication. So, it is clear that the use of supplementary teaching materials about the immune system in learning is useful for improving students' skills in communicating in writing.

Assessment of the student's written communication skills by assessing this product is in accordance with the government's appeal in Permendikbud number 23 of 2020 article 2 [22]. The Permendikbud explains that assessment is the process of collecting and processing information to measure the achievement of student learning outcomes. Student learning outcomes referred to in this research are communication skills and critical thinking skills.

2. The student's critical thinking ability and the communication skills

The critical thinking skills of students in this study were obtained from the results of students' tests in working on the questions using the Quizizz application. The test result data were analyzed using the N-gain test, then used to measure students' critical thinking skills. The results of the analysis show that the average level of the students' critical thinking ability is in the medium category. A total of 27.78% of

students have the critical thinking ability level with critical and very critical categories, 33.33% are in the medium category (quite critical) and the rest (38.89% are categorized as less critical. If averaged, the percentage of students' critical level is 52.52%. This description is in accordance with the results of the analysis used the N-gain test which showed the percent N-gain score of 32.70 (moderate category). Thus, it can be stated that the students' critical thinking ability can be improved by learning that using the ICT-oriented PBL, especially on the immune system material.

Isnaeni *et al.* [18] found that the problem-based learning (using worksheets) had a significant effect on increasing the student's HOTS. This is in accordance with the results of Lee's research [23] which states that worksheets are useful for adding information and can attract the students' interest to find out various things that are useful for forming their thoughts. Some other findings that support this explanation are that 1) the use of higher order thinking skills can increase the student motivation, (2) involving students in the problem-solving activity can optimize the students' thinking skills. The problem-solving process is also able to train them to think critically and creatively [24-26].

In the learning process which using the PBL approach students carry out the learning activities with the help of worksheets, and they succeed in achieving low-level thinking skills. Mastery of low-order thinking skills is a strong basis for improving the higher-order thinking skills in students, which is shown by their ability to solve problems. The higher order thinking skills need to be based on the lower order thinking skills such as discrimination, application, simple analysis, and cognitive strategies related to prior knowledge of the content of the subject [27].

In this study, the facilitation of communication skills occurred in the activities in one of the steps / learning syntax, namely in discussion activities. In the discussion activities that carried out by all groups, teachers facilitate and train students in verbal communication. In the presentation of the results of the discussion carried out through the WA group (in the large group), students are conditioned to write down the statements to be presented. This means that during the series of group discussion activities to the presentation of the results of the discussion (class discussion), students are accustomed (trained) to do written questions and answers and analyse the results of the discussion with the teacher and other students. Thus, it can be emphasized that the learning process with PBL is useful for training the students' HOTS, especially the critical thinking skills. In such conditions, students need to have several supporting skills, namely communication skills (especially in the written communication). Indicators of the written communication skills include the ability/skills in the taking core information, making observations, and presenting the knowledge that they have acquired.

Practicing the higher order thinking skills in students can be done by exposing the students to a problem that has not been recognized [28] [4]. In this condition, students are challenged to use their thinking skills to find a way out of the problems they face. Liu [4] stated that the assessment and the learning are two inseparable things. The assessment is an integral component of the science learning process, inseparable from one another. This means that the learning and the assessment process must match. If the teacher aims to practice the critical thinking skills, the process of measuring the learning outcomes must also use the appropriate special instruments.

Referring to Liu's opinion [4], the measurement of the student's critical thinking ability in this study was measured using the assessment instrument with HOTS criteria. Critical thinking skills are based on an analysis and evaluation skills. The students' written communication skills are measured by the quality of products that produced by students. The products in question are the scientific reports and posters. The aspects of the scientific report that are assessed include aspects of the cover, problem formulation, objectives, general theory, tools, discussion, conclusions, suggestions, and references. The poster aspects are assessed include content / text, the design, the images, and the message delivery. The results of the assessment to the quality of the product indicated that the level of the student's communication skills in writing was categorized as very good, with an average value of 83.00. This shows that the student's critical thinking ability and the written communication skills can be facilitated by a learning process with an ICT-oriented PBL approach.

In this study, students' critical thinking skills were measured using Quizizz-based tests, which are interactive, and which are useful for supporting the learning process in the classroom [16]. Using quiziz

in tests (means using technology) has been proven to positively increase students' knowledge [16], also makes students excited in understanding lessons and is able to increase student independence [17].

The results also showed that the learning process using teaching materials with the ICT-oriented PBL approach and assessment instruments with HOTS criteria received positive responses from students and teachers. The teacher believes that the learning process carried out in this study is useful for facilitating the student's critical thinking ability and the communication skills. Students think that the teaching materials that used are easy to understand (easy to read) and practical.

4. Conclusion

The Students' critical thinking ability and the written communication skills can be improved by a learning process that uses the ICT-oriented PBL teaching materials and the assessment instruments with HOTS criteria.

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