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Development of Interactive E-Workbook Based on Peer-Led Team Learning on Collaboration Skills and Critical Thinking in Basic Chemistry Concept

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Abstract

Many students struggle to understand chemistry because it is abstract, conceptual, and involves numerous mathematical operations. Collaboration skills are needed for students to develop collaborative and critical thinking as part of 21st century life skills. This study aims to develop an interactive e-workbook based on PLTL (Peer-Led Team Learning) that meets the criteria of being valid, practical, and effective against collaboration and critical thinking skills. This research is an ADDIE-based development research with analysis, design, development, implementation, and evaluation stages. Limited trials were conducted on students in basic chemistry classes. The validation results show that e-workbook is valid, practical, and effective. The results of limited trial showed that collaboration skills improved in the good category with average score is 75%, and critical thinking skills improved in the medium category with average score is 0.33. It shows that the interactive e-workbook based on the PLTL model can improve collaboration and critical thinking skills and can be used to solve problems in group discussions with the help of an expert leader.

Keywords: collaboration skill, critical thinking skill, e-workbook, peer-led team learning

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1. Introduction

The 21st century is called the century of globalization which is marked by the rapid development of information technology. In the 21st century, there was also the industrial revolution 4.0 which has recently shifted to the era of society 5.0, which is the concept of humans collaborating with technology to solve integrated social problems in virtual and real-world spaces (Teknowijoyo & Marpelina, 2021). These developments do not only occur in the industrial sector but have an impact on all aspects of life, including education. Education as the main pillar in producing professional human resources are required to have expert teaching and learning skills in the 21st century (Mardhiyah et al., 2021). The use of Internet of Things (IoT)-based teaching materials that are able to build skills in accordance with 21st century life skills are indispensable in the learning process (Redhana, 2019).

One of the learning processes that can be taken is basic chemistry in universities. In the Indonesian curriculum, basic chemistry II is a continuation of the basic chemistry courses taught in the previous semester. A good understanding of the concept in the two courses will greatly assist students in understanding concepts in the next semester. Concepts in basic chemistry II courses in the chemical education study program include hydrolysis, colloids, chemical equilibrium, thermodynamics, solubility products, redox, electrochemistry, and polymers. Thus, it is concluded that basic chemistry II includes abstract concepts and the other that requires

mathematical operations and material that emphasizes analytical thinking. So, it takes sufficient capability and competence to be able to understand the concepts well (Üce & Ceyhan, 2019).

Based on interviews with 2018 and 2019 chemistry education students who have studied basic chemistry II and conducted research on learning outcomes, it was found that some students had low basic concept and mathematical analysis skills that caused difficulties in learning, such as in solubility products and electrochemistry. In addition, students stated that the lack of learning concepts that were easily accessible anywhere and anytime so that students did not repeat the material taught at home because there were no specified learning resources, students only recorded the teacher's explanations while the approach applied used direct learning where learning tends to be dominated by teachers to explain the concept that causes students to be more passive and feeling bored without giving students the opportunity to be actively involved in learning either directly or exchanging ideas with their friends (Yuberti, 2014).

To overcome that problem, it is important to build a new strategy. One of the strategies is the application of cooperative approach where students can exchange ideas, ask friends if there are concepts that have not been understood. In addition, students also conduct joint learning and complete joint assignments regarding the assignments of the chemical material obtained. It also requires the presence of a leader or an expert who monitors, facilitates, and motivates students in understanding basic chemistry II. So that, student collaboration skills can be formed both outside the classroom and in the learning process. Collaboration skills are the ability of a person to participate in an activity in order to foster relationships with others, respect each other, and collaborate to achieve the desired goals. Collaboration is also defined as the ability to act effectively, accountability, a sense of concern among members in team work to achieve common goals (Hidayanti et al., 2020).

Many conducted researches related to critical thinking and collaboration skills, for example Anwar et al. (2017) stated that group learning by giving jumping tasks can increase collaboration, mutual respect among group members, and students are able to improve problem solving skills so that they have high critical thinking skills. Yudhanta et al. (2021) stated that group learning with the STAD (Student Team Achievenment Division) type was able to increase collaboration in working together in exchanging opinions to solve existing problems so as to foster students' critical thinking skills. Sanchez et al. (2014) stated that collaborative learning can improve critical thinking skills.

A cooperative approach that can affect collaboration and critical thinking skills can be expressed in a PLTL (Peer Led Team Learning) model. PLTL is a learning model to develop their own knowledge through collaboration with others through the help of a peer leader who will assist, review, and monitor learning progress (Lewis, 2011). In line with Carlson et al. (2016) stated that the PLTL model is a cooperative learning model by utilizing peer leaders who are experts in their fields as facilitators. In addition, the PLTL model is a model built from constructivism learning theory and balance theory, which means that all members in the group must practice building concepts, negotiating, evaluating, and correctly understanding the material given (Smith et al., 2014). Previous research stated that the PLTL model was able to provide time and space for students to engage more in solving problems under the leadership of more advanced and experienced colleagues (Carlson et al., 2016), increasing learning motivation and cognitive abilities with the help of a leader (Anwar & Hariantini, 2019), improve critical thinking skills (Stephenson et al., 2019), and create a more productive environment for students to develop and maintain positive social interactions with their peers (Eren-Sisman et al., 2018). So that with the application of the PLTL model, students

are expected to be able to construct their own material based on experience through study groups guided by peer leaders. In addition, each group member has a learning experience or understanding of the material that is equivalent or comparable to that of other group members.

To support the effectiveness of the application of the PLTL model, teaching materials are needed in accordance with the syntax, such as the use of learning materials in accordance with the sequence of steps of the PLTL model, where the learning materials in question consist of a collection of materials and enrichment questions that can be done individually or groups, and can be accessed anywhere and anytime. Several studies related to innovation in the development of technology-based learning materials, Saviyanah et al. (2017) which developed a science workbook on process skills and student learning outcomes, while Herowati and Azizah, (2019) developed a contextual-based science learning media workbook that can be used in the learning process specifically in chemistry learning. It has also been carried out, for example an e-worksheet that integrated problem solving on the reaction rate material can improve student learning outcomes (Gultom & Muchtar, 2020). E-modules on atomic structure materials can improve the quality of online learning (Mufida et al., 2022). E-books consisting of images, animations, or videos are able to meet the three levels of chemical representation, which are macroscopic level, submicroscopic level, and symbolic level (Tania & Fadiawati, 2015). The technology-based teaching materials that have been developed are proven to have a positive impact on the progress of students' skills and learning outcomes.

Interactive e-workbook is learning material in the form of an e-workbook containing material that is presented interactively to make it more interesting so as to increase interest in learning, ability to understand material and make it easier to access. In addition, it contains many practice questions where students will be trained in solving structured questions in groups so that they can practice collaboration skills that will increase understanding of the stages in problem solving (critical thinking skills) (Ardiyansyah et al., 2019). Making interactive e-workbooks can be done using a software called Kotobee as a solution for creating, managing, and sending interactive eBooks in various formats. The four Kotobee products and services comprise the Kotobee Platform: Kotobee Author, Kotobee Cloud, Kotobee Library, and Kotobee Reader (Kotobee, 2021).

Based on this description, and strengthened by the research conducted by Aima and Rahima, (2020); Frey et al. (2018); Hidayanti et al. (2020); Stephenson et al. (2019) the things that make the difference or the novelty of this study. Firstly, there has been no development of teaching materials based on PLTL models, secondly there has been no development of interactive basic chemistry electronic workbooks (interactive e-workbooks), and thirdly there has been no measurement of collaboration skills. Therefore, it is important to do this research to develop interactive e-workbooks based on PLTL for collaboration and critical thinking skills of chemistry students. The output of this study is an interactive e-workbook based on the PLTL model that meets the criteria of validity, practicality, and effectiveness for students' critical thinking and collaboration skills.

2. Research Method

This research is a development research that conducted ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model (Tegeh et al., 2014).

2.1. Analysis Phase

Performance analysis and needs analysis to find out and classify basic chemistry learning problems, as well as knowing the needs of students and educators for teaching materials in chemistry learning to be able to attract and increase collaboration and be able to hone critical thinking skills.

2.2. Design Stage

Making an interactive e-workbook design through course learning achievement analysis, determining the application used, and determining the team of experts involved in the development process.

2.3. Development Stage

This stage aims to produce a feasible interactive e-workbook product. The components developed are the introductory section, the contents of the material in the form of videos, animations, and pictures closing in the form of a glossary and attachments. The interactive e-workbook that has been developed is validated by experts. Based on the expert's assessment, it is then revised and re-validated until the product developed is declared valid.

2.4. Implementation Stage

This stage aims to implement products for students who are studying basic chemistry on solubility products, electrochemistry, redox and polymers based on the syntax of the PLTL model. The learning steps use the PLTL model, which are providing motivation and learning objectives, presenting material, organizing in study groups and determining leaders, completing assignments, conducting individual evaluations and giving awards (Gosser et al., 2001).

At this stage, data was also obtained regarding the practicality and effectiveness of the developed interactive e-workbook as well as collaboration and critical thinking skills. Practicality was measured using observation sheets for student activities and lecturer activities while effectiveness was obtained from three ways, which are student responses using questionnaires, collaboration skills using observation sheets, and critical thinking skills using written tests. The collaboration skills observation sheet includes indicators in the form of contribution, time management, problem solving, cooperation, and investigation techniques.

Analysis of critical thinking skills tests using the one group pretest-posttest method. The tests given are in the form of description questions covering the material solubility product, polymer, electrochemistry, and redox. So that the number of items is four numbers. Each question is made in a complex manner which contains indicators of critical thinking in the form of describing, criticizing, evaluating, reflecting, analyzing, and reasoning (Changwong et al., 2018). The guideline for scoring each item uses the level of cognitive questions that adheres to the guidelines from Zubaidah et al. (2015). The difference before and after treatment is through the gain score. Then, the initial tests are homogeneity and normality tests as prerequisites and the last is the paired sample t-test as a significance test through SPSS Statistics 26.

The assessment used on the validation sheet, observation sheet and questionnaire use Likert scale using numbers 1-4, 4 = very good, 3 = good, 2 = less and 1 = very less. Furthermore, from the results of the analysis, the average value of the total aspects for all indicators was determined for validity, practicality and effectiveness, especially for student responses and collaboration skills. The average total value is converted into categories according to Widoyoko (2012).

2.5. Evaluation Stage

This stage aims to make a final revision of the product developed based on suggestions and input during the implementation stage

3. Result and Discussion

The needs obtained from the results of the analysis using interview techniques and tracing student learning outcomes are then followed up by developing teaching materials in the form of interactive e-workbooks based on the PLTL model. The process of designing or developing an interactive e-workbook use the Kotobee Authors application because it has a relatively low file size that make it easy to use the application including the installation process on a laptop, providing an export file form to Android, iPad, iPhone,

HTML5, desktop, and another Learning Management System (LMS).

The design of interactive e-workbook component includes three sections, which are introduction, content, and closing section while the number of e-workbooks designed is four files. The first is the material of solubility product with a discussion of the concept of solubility and solubility product, precipitation prediction, namesake ion effect and complex ion equilibrium. The second is polymer material with discussions in the form of polymer concepts, synthetic organic polymers and natural polymers. The third is electrochemical concept with discussions related to galvanic cells and electrolytic cells. The fourth is redox concept with discussions related to redox concepts and equalization.

The initial development results using the Kotobee Authors application have been carried out in Figure 1.

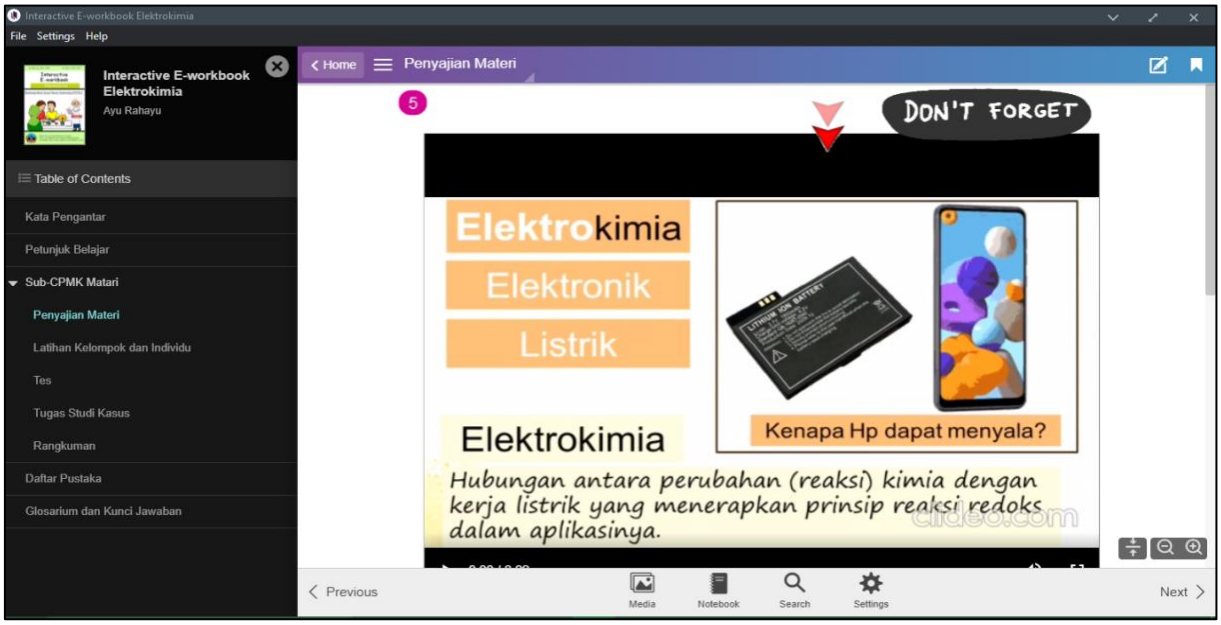

Figure 1. Initial Results of Interactive E-Workbook Development Using the Kotobee Authors Application

The interactive e-workbook that has been developed is then validated in terms of material, design and language. Some input from the validator includes the learning videos used that should be added with audio explanations so that students can better understand the chemical material of the e-workbook components paying attention to the syntax of the PLTL model, the scope of the material is further deepened so that later they can improve students' thinking skills. Based on this input, improvements were made, then re-validation was carried out. So that the validation results are obtained in Table 1 and the final product of the development in Figure 2.

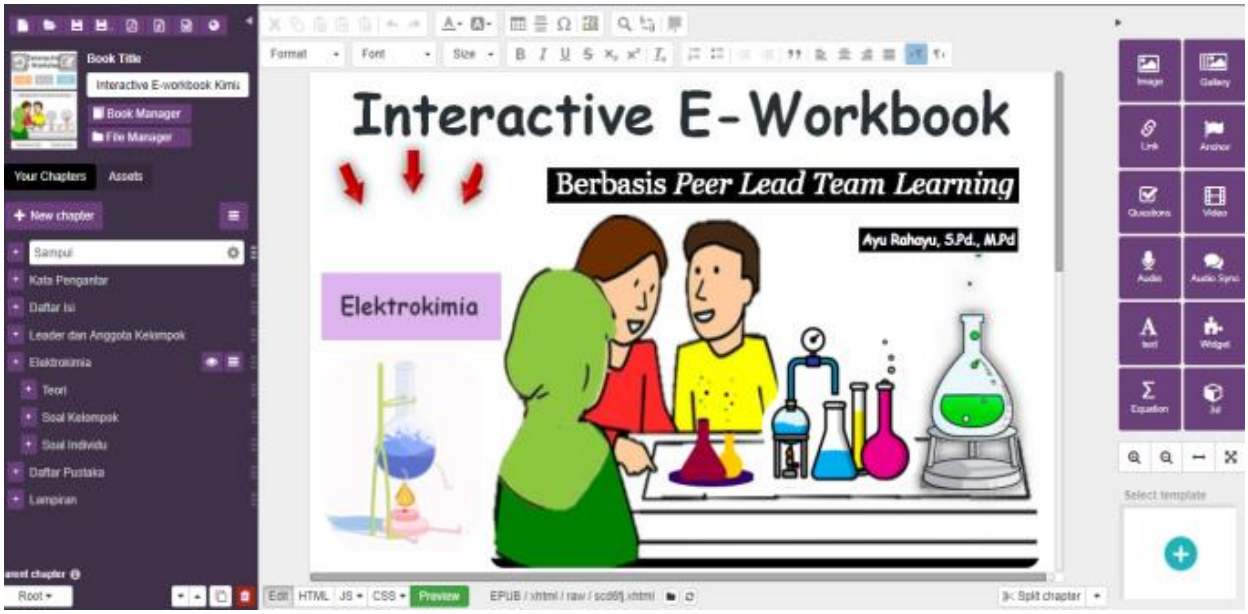

Figure 2. Interactive E-Workbook Final Display

The distinctive feature of the e-workbook development is the preparation of components that follow the steps of the PLTL model. The first part includes the cover, preface, and study guide. The second part includes learning objectives, presentation of material in the form of interactive videos, group and individual practice questions, tests, case study assignments, and summary. The third part includes a table of contents and attachments.

The results of the assessment of three validators in Table 1 show that the PLTL-based interactive e-workbook is declared valid in terms of material, language and design with several inputs. The material expert's assessment showed that the material presented had material studies that were in accordance with the sub-course learning of basic chemistry learning and the presentation of the material was in accordance with the steps of the PLTL model and included aspects of collaboration and honing critical thinking skills. The assessment of linguists shows that the preparation of the interactive e-workbook in terms of language is easy to understand, according to the rules of the language, accuracy of sentence structure, accuracy of spelling, and consistent use of terms.

Table 1. Analysis of Validity Result

Evaluator	Rated Aspects	Score	Average Score	Category
Concept Expert	Quality of content and purpose	2.57	2.67	Good/valid
	Quality of learning process	2.75		
	Display of material	2.66		
	Concept up to date	2.66		
Design Expert	Cover display	2.57	2.88	Good/valid
	Content display	3		
	Aspect of use	3.08		
Language Expert	Communicative	3	2.66	Good/valid
	Readibility	2.6		
	Straightforward	2.4		

Communication delivered by the communicator in writing or verbally must use effective language to create good performance (Waridah, 2016). The design expert's assessment shows that the preparation of interactive e-workbooks using the Kotobee application contains aspects of reliability, maintainability (can be managed easily), reusability (easy to use and simple to operate) and compatibility (learning media can be installed/run on various existing hardware and software). As said by Alfian et al. (2019). that the development of software-based media or software must include maintainability in the form of analyzability and changeability, portability, which is testing in running applications on several types of devices and usability. Based on these assessments it can be stated that the interactive e-workbook based on the PLTL model in terms of language, material and design is feasible to try out.

A valid guide means that it is feasible to try out, the implementation phase will provide practical and effective data. The implementation stage is an important stage because students are the target of the developed product test. The implementation stage presents two data, practicality in Table 2 and effectiveness in Table 3.

Table 2. **Results of Practicality Data Analysis**

No	Assesed Components	Average Score	Category
1	Lecturer Activity	3.71	Very Good
2	Student Activity	3.67	Very Good

The results of data analysis in Table 2 can be concluded that the use of an interactive e-workbook based on the PLTL model is practical or easy to use starting from the preliminary activities, the core activities carried out according to the syntax of the PLTL model to the closing activities. The observation results show that students actively participate in the learning process and foster motivation and a spirit of cooperation to collaborate in understanding the material with the help of the leader so that they are able to solve problems properly. This can be attributed to the characteristics of the PLTL model. Cracolice and Deming (2005) suggested that the PLTL model forms a learning environment where students can have the opportunity to play an active role in the learning process. Students easily ask questions, collaborate, discuss and express ideas in groups. A conducive learning environment can help students gain a deeper understanding of the material being taught, thereby increasing the level of meaningful student learning (Arianti, 2017). This is evidenced by the results of research which states that the PLTL model can improve problem-solving abilities (Snyder & Wiles, 2015), increase conceptual understanding (Bramaje & Espinosa, 2013), and increase learning motivation and student learning engagement (Lamina, 2021).

Table 3. Data for Student Response Analysis

Assesed Aspects	Score	Average Score	Percentage	Category
Use of Interactive E-workbook	3.73			
Benefit Interactive E-workbook	3.63	3.65	89%	Good
Understanding Concept with PLTL Model	3.58			

According to the research results in Table 3, it was found that students gave good responses. The positive response implies that students are interested in using PLTL-based interactive e-workbooks and are enthusiastic about participating in learning activities as evidenced by comments such as the use of e-workbooks really helps understand material

from videos and tests understanding with available questions, increases collaboration, because you can study anywhere and anytime, and the presence of a leader makes the learning atmosphere not boring and helps in understanding the material. The use of digital-based teaching materials in the learning process becomes more efficient because there are audio visuals that are easy to understand compared to printed teaching materials (Dinatha & Kua, 2019). As well as with the guidance of someone who is more expert, it can help increase learning motivation so that understanding of learning is better, both from the cognitive, affective and psychomotor domains (Purba et al., 2020). Based on student responses, it can be concluded that PLTL-based interactive e-workbooks are acceptable for use in the learning process, especially in basic chemistry courses.

At the implementation stage, data on collaboration skills is also obtained in Table 4.

Table 4. Results of Collaboration Skills Data Analysis

Collaboration Indicators	Concept				Vi	Percentage	Category
	1	2	3	4			
Contribution	3.3	2.9	3	3.5	3.17	79%	Good
Time Management	3.9	4	3.8	4	3.92	98%	Very Good
Problem Solving	3.4	3.1	3.2	3.1	3.20	80%	Good
Collaboration	2.9	2.2	2.3	2.5	2.47	62%	Average
Investigation Technique	2.1	2.3	2.3	2.1	2.20	55%	Average
Average						75%	Good

The data in Table 4 shows differences in each indicator of collaboration skills. The first indicator is contribution, meaning that students are able to provide ideas and contribute from learning activities in the good category. This is supported by the results of observations of the learning process where the stimulus given by the lecturer is able to be responded to by students well so that the learning process occurs in two-way interactions. This was emphasized by Safrida et al. (2017) the involvement of students is needed in the learning process in order to create active and effective learning. The second indicator is time management, meaning that students are able to complete assignments on time in groups in the very good category. Giving a time limit is needed so that the learning process goes according to a predetermined plan. In addition, students who are able to manage their time well will have regularity in studying so as to form a self-discipline (Apriyanti & Syahid, 2021). The third indicator is problem solving, meaning that students are able to make clear efforts to find solutions to answer problems in the good category.

The observation results show that students seriously complete calculation problems, for example in the chemical precipitation material contained in the e-workbook with the help of the leader.

Problem solving skills are really needed in solving chemistry problems, especially problems of mathematical calculations (Nuralifah & Hidayah, 2020).

The fourth and fifth indicators are in the sufficient category, which are collaboration and investigative technique. Its meaning that students' ability is still low in helping find solutions to other friends and looking for other relevant references to produce detailed and accurate information. The category is sufficient because students only rely on the presence of a leader who is believed to be able to help solve existing problems so that collaboration with other group mates is only done occasionally and does not search for additional references even though solving existing problems is not enough, just one reference but various other representative references are needed. Some things that are

needed to establish cooperation include the need for arrangements related to coordination between group members including the division to find various references that can be used as a benchmark in discussions, each member must be aware of the abilities possessed and must be able to establish good communication (Setiyanti, 2012).

Based on the description of each of these indicators, it is stated that the use of interactive e-workbooks that have been developed using the PLTL model can improve student collaboration skills with an average percentage of 75% in the good category. One alternative in overcoming learning difficulties, especially in chemistry learning, is to hone student collaboration skills (Hidayanti et al., 2020). The use of teaching materials such as student worksheets supports the successful formation of collaboration skills (Nurwahidah et al., 2021). Collaboration skills will increase if done in group learning activities (Apriono, 2013). Collaboration skills can be formed in the use of the PLTL model, this is in accordance with the results of the analysis of Biggers et al. (2009) suggesting that the presence of a leader in the PLTL model makes it easier for someone to collaborate in groups while Pazos et al. (2010) group learning led by leader is a feature of the PLTL model that has shown consistent success in increasing collaboration, especially in the disciplines of science, technology, engineering, and mathematics.

The analysis of critical thinking skills tests was carried out using the one group pretest-posttest research design and was measured using a test instrument. The test given is a description test based on indicators of critical thinking skills including describing, criticizing, evaluating, reflecting, analyzing and reasoning.

The results of the pretest and posttest tests for measuring critical thinking skills were first carried out by the initial test, which are the normality and homogeneity tests as prerequisite tests. The results of the normality and homogeneity tests show that significant value is greater than 0.05 so it is concluded that the data obtained to measure students' critical thinking skills is normally distributed and has a homogeneous distribution.

The t-test is a smaller significant value than 0.05 so it can be concluded that the use of interactive e-workbooks based on PLTL as a result of the development can improve students' critical thinking skills. The increase in critical thinking skills can be compared before the value of the treatment or pretest and after the treatment or posttest by using the score gain test. The results of the score gain test are shown in Table 5.

Table 5. Gain Test Results Indicator Score Critical Thinking Skills

Critical Thinking Skill Indicator	Gain Score Test			
	S-pre	***S-post***	***N-gain***	**Category**
Describing	42	65	0,40	Medium
Reflection	71	87	0,54	Medium
Analyzing	59	63	0,11	Low
Criticizing	38	62	0,39	Medium
Reasoning	41	46	0,09	Low
Evaluating	75	86	0,47	Medium
Average			0.33	Medium

Critical thinking skills are measured using pretest and posttest essay tests. The data in Table 5 where the N-gain shows differences in each aspect of critical thinking which can be classified into two categories, which are medium and low. The four indicators in the medium category are describing, reflecting, criticizing and evaluating, meaning that students are able to describe clearly, in detail and specifically, reconsider topics with new information, identify and examine the weaknesses or strengths of concepts, and comment on the level of success and failure of something.

While the low category, which are analyzing and reasoning skills, means that students are not proficient in examining and explaining how something is and using methods such as cause and effect to show logical thinking, and present evidence. These two aspects are in the low category because in learning students if they find difficulties, they can ask the leader so

that they are directed to find answers quickly, the leader should only provide a stimulus and an image does not provide an answer. The PLTL model will be successfully applied if it is supported by a leader who has great patience in guiding his group members without telling them the correct answer (Bramaje & Espinosa, 2013) and is trained in pedagogy, material knowledge, and leadership roles (Quitadamo et al., 2009).

The results of the recapitulation of critical thinking skills are obtained in the medium category, this is because the leader is only involved in the learning process so that continuous learning does not occur in completing the assigned tasks. According to Gaffney group learning led by a leader must be an integral and coordinated part in facilitating group work (Bramaje & Espinosa, 2013). However, in general it can be concluded that interactive e-workbooks based on PLTL models can improve critical thinking skills. This is appropriate. with the results of the analysis by Wilson and Varma-Nelson, (2016) which states that critical thinking skills are skills that can be trained and developed where the PLTL model is effective in increasing them. According to Stephenson et al. (2019) critical thinking skills can be improved by applying PLTL and Science Writing and Workshop Template (SWWT) which combine writing, discovery, collaboration, and reflection skills. In addition, according to Quitadamo et al. (2009) the PLTL model helps students who have low thinking skills caused by collaboration between teams.

The implementation phase illustrates that the Interactive e-workbook based on the PLTL model received a positive response from students, increasing collaboration and critical thinking skills. Some of the suggestions obtained from the implementation stage are optimizing the role of the leader and operating the interactive e-workbook using android. Based on this, the researchers assessed that the Interactive e-workbook based on the PLTL model that was developed was more successful in increasing collaboration skills and critical thinking skills.

Some of the improvements for the next stage are; first, the role of the leader does not only occur in the classroom but outside the classroom to form a sustainable learning community. In addition, the selection of leaders must pay attention to several things, such as leaders are people who have social skills, have mastery of the material and have a good leadership spirit, and can motivate students to be enthusiastic about solving existing problems. Second, carry out further development of the Kotobee author application so that the operation of the Interactive e-workbook does not only use the Kotobee reader application but also web applications, mobile applications and is integrated with the LMS.

4. Conclusion

The quality of PLTL-based interactive e-workbook development refers to the ADDIE model, which is valid (an average score for collaboration and critical thinking skills are 75% and 0.33, respectively) from the assessment of material, language, and design experts. It shows that all aspects of learning activities can be carried out, students give positive responses, and have good collaboration skills. Further strategies needed to increase collaboration and investigative techniques. E-workbook based PLTL can be a solution as student learning material that can be accessed anywhere and anytime by presenting interactive material in the form of video, audio, animation, and 3D images. Besides that, it can make easier for students to collaborate with peers with the help of leaders in solving existing problems or case studies.

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