Constructivist Computer-Based Instruction (CBI) Approach: A CBI Flipped Learning Integrated Problem Based and Case Method (PBL-cflip) in Clinical Refraction Course

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Abstract—Based on the preliminary study, it was revealed that students have less competence of critical thinking skills, creativity, and learning outcomes in clinical refraction courses. In 21st-century learning, students must master the critical thinking, communication, collaboration, and creativity (4Cs) skill as recommended. Because of this phenomenon, it is critical to implement the appropriate learning approach; one solution offered is CBI Flipped Learning Integrated Problem-Based and Case Method (PBL-cflip). This study aims at describing the effectiveness of the CBI Flipped Learning Integrated Problem Based and Case Method (PBL-cflip) in improving student learning outcomes in clinical refraction courses. This research was quantitative, which using a quasi-experimental method. There were 61 vocational education students who took the clinical refraction course who participated in this study. The results showed an increase in students' critical thinking, collaboration, communication, and creativity skills, which helped them achieve the expected learning outcomes. It can be concluded that PBL-cflip is useful for students to understand and solve cases in clinical refraction courses and can create an interesting learning atmosphere according to student interests, students can be more enthusiastic to participate in learning. The novelty of this study depicts that problem-based CBI, which is implemented in a flipped, whereas previous studies have not focused on implementing problem-based in a flipped manner.

Keywords—computer-based instruction (CBI), flipped learning, problem-based learning, case method

1 Introduction

Today's globalization has brought changes to people's lives as a whole, especially in higher education. 21st-century education faces complex challenges and evolving

personal needs [1]. The current focus of 21st-century skills includes creativity, critical thinking, communication, and collaboration, which are called 4C [2]. Therefore, the world of education has to create ways for students to acquire 21st-century skills in the era of the 4.0 revolution. The plan includes student skills—creative, innovative, and communication and collaboration skills (4C)—that allow students to think critically when solving problems [3].

In fact, there are still many students in Indonesia who lack in the 21st century skill, the average score of students' problem-solving abilities is below the average problem-solving ability score set by PISA [4]. According to the Martin Prosperity Institute survey results in the 2015 Global Creativity Index, Indonesia is ranked 115th out of 139 countries. It means that the level of creativity among students in Indonesia compared to other countries is still low [5]. In addition, vocational education students graduate with less experience in problem-solving, critical thinking skills, communication, and creativity, but more textbook knowledge [6]. In fact, in the 21st century, students are expected to master the 4Cs skills [7].

One of the factors that 4C skills not be mastered optimally because of the implementation of learning methods. Traditional learning methods, may not adequately prepare students to master these expected skills [8]. The students who educated today are technology generation students, who are used to using technology in everyday life and will feel bored if the learning process only focuses on conventional methods [9].

Therefore, a new educational approach is needed, and CBI Flipped Learning Integrated Problem Based and Case Method (PBL-cflip) is one of the solutions that can be implemented in learning to make it better. Research in recent years has highlighted the effectiveness of using computers and problem-based learning in improving learning outcomes [10], communication and collaboration [11], creativity and critical thinking skills [12]. The novelty of this study depicts that CBI integrated with the Problem Based and Case Method, that implemented in a flipped manner and utilizing technology, it can be accessed by students anywhere. Previous problem-based learning research has not resulted in flipped implementation or the use of CBI [13]–[15]. So, this study aims to see the effectiveness of the CBI Flipped Learning Integrated Problem Based and Case Method (PBL-cflip) in improving student 4C skill in clinical refraction courses.

2 Method

2.1 Research types and procedures

The type of this research was quasi-experimental and uses the pretest-posttest control design method [16]. The pretest was examined to students before implementing PBL-cflip, it determined the students' initial abilities. After that, the PBL-cflip was implemented to students for 10 weeks, and in the 11th week, a posttest was given [17]. This study used the flipped CBI method, which is integrated with the problem-based and case methods. The flipped method used requires students to study at home by online, and solving problems or cases conducted face-to-face at class. Students are

given problems or cases in the CBI software, which allows them to develop their knowledge by solving problems.

This PBL-cflip syntax was implemented for 2 weeks for 1 cycle, which means that PBL-cflip uses one case type for one week [18]. The procedure of PBL-cflip that implemented refer to Table 1. Table 1 explains that student orientation activities, students are given learning material to understand it independently (syntax 1). Then, the educator will provide a case and students will diagnose the case (syntax 2). Based on the diagnosis, students will develop an action plan (syntax 3) and collect information related to the case (syntax 4). These four activities are conducted online by students. In the following week, students will conduct face-to-face learning, they will report the best solution and evaluate cases (syntax 5 and 6) [19].

Table 1. PBL-cflip syntax

Syntaxes	Activities	Method
Step 1 Introducing cases to students	Lecturers provide basic concepts, and instructions that used in learning and students read the material provided and discuss it with friends (Collaborative, Communicative)	First Week: Online Learning CBI using
Step 2 Diagnosing cases	Students analyze the causes of problems and analyze various factors, inhibiting factors that can support problem-solving (collaborative, critical thinking, creative)	First Week: Online Learning CBI using
Step 3 Designing the action plan	Students make a list of data which is the basis for problem identification (creative)	First Week: Online Learning CBI using
Step 4 Collecting information/data	Students analyze problems critically, namely describing or elaborating data, compiling estimated answers (hypotheses) (critical thinking, creative, communicative)	First Week: Online Learning CBI using
Step 5 Choosing the best solution	Students share information through collaborative, creative, critical thinking, and communication and have developed a solution to the problem (creatively)	Second Week: Face-to-Face Learning peer teaching/ cooperative learning
Step 6 Evaluating cases	Students review what they have learned in the process with group members (creative and critical)	Second Week: Face-to-Face Learning reflection
Step 7 Solution Presentations	Each group makes a presentation about the solution to the case (creative, communicative) and lecturers will provide feedback	Second Week: Face-to-Face Learning Presentations
Step 8 Reporting the solution	Students report the results of group investigations (creative, communicative, and collaborative)	Second Week: Face-to-Face Learning Report

2.2 Research participants

There were 60 vocational education students who took the Clinical Refraction Course who participated in this study, which was divided into two groups: 30 students of control group and 30 students of experimental group. The experimental group will be implemented PBL-cflip, while the control group will implement the teacher-centered learning (TCL) method. 60 participants in this study were selected using the simple random sampling [20], in which 125 students as population and all populations have the same opportunity to be sampled. For more detail, the sample data for this study can be seen in Table 2.

Table 2. Research participants

Group	Total of Students		Sub-Total
	Male	Female	
Experimental	14	16	30
Control	15	15	30
Total			60

2.3 Data collections

Essays will be used as achievement test to see the increase in problem-solving and critical thinking skills [21], as well as a rubric for assessing communication and collaboration skills [22]. The aspects of understanding, analysis, and reasoning will be including in essay test. Aspects of student knowledge (learning outcomes) are measured based on the scores obtained by students from the essay test. The questions are designed to encourage higher order thinking (HOT), with C3 (apply), C4 (analyze), and C5 (evaluate) [23].

Before this test was examined as a pretest and posttest, a pilot test was conducted to explore the instrument validity. The results of the Cronbach alpha analysis showed that the reliability value being 0.86, which is an acceptable level, and the difficulty level of the item being 0.55, which is not at a difficult or easy level.

2.4 Data analysis

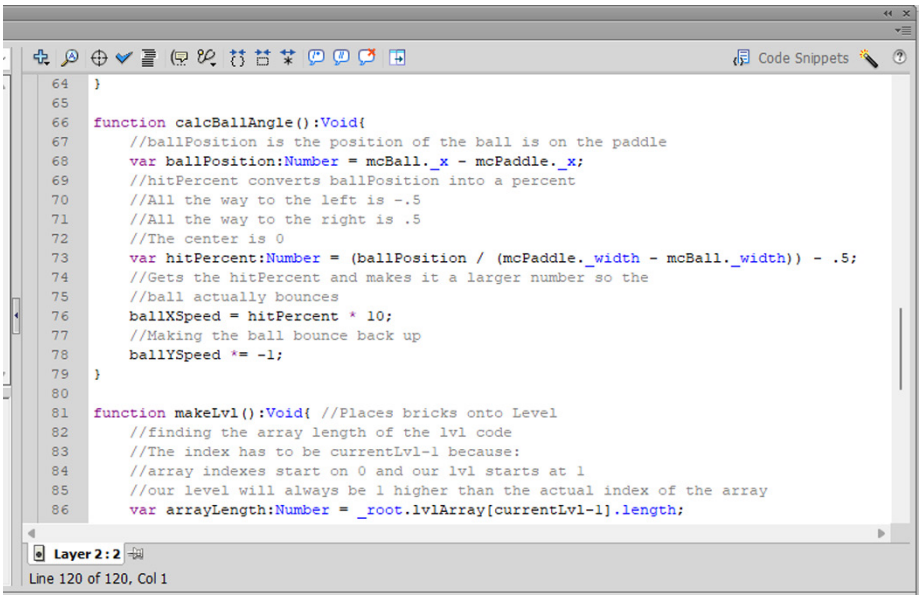
Statistical parametric were used in analyzing the data; t-test to see the comparison of 4Cs skills between the control and experimental groups per variable [24], the ANOVA to see the comparison of 4Cs skills together between the control and experimental groups [25], as well as the gain score to see the increase of student abilities [24]. The research hypothesis was follows:

H01: There is no statistically significant difference in problem-solving ability between the control group and the experimental group
H02: There is no statistically significant difference in critical thinking ability between the control group and the experimental group
H03: There is no statistically significant difference in collaboration skills between the control group and the experimental group
H04: There is no statistically significant difference in communication skills between the control group and the experimental group
H05: There is no statistically significant difference in learning outcomes together in the 4Cs abilities between the control group and the experimental group.

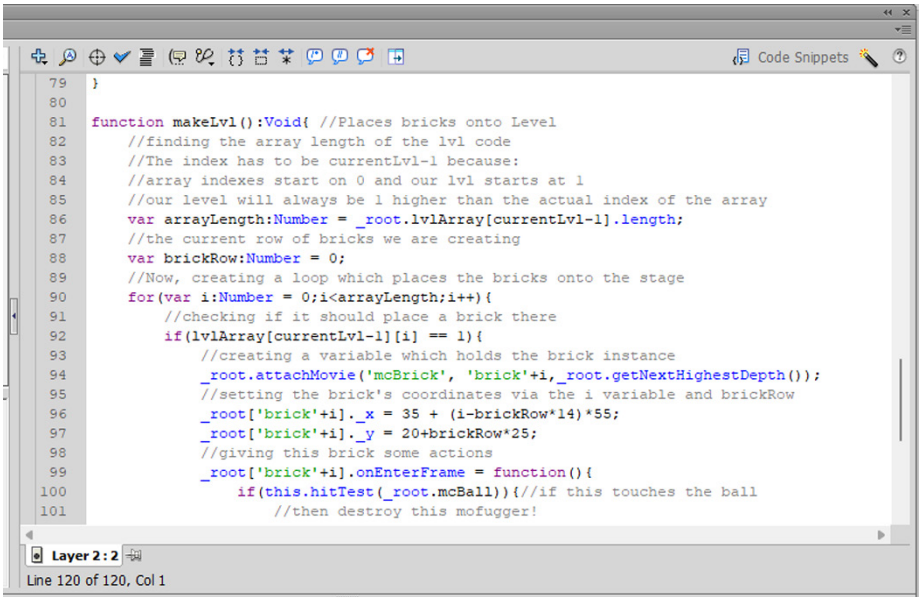
3 Results and discussion

Constructivist CBI integrates problem-based learning and case studies, providing learning with a variety of teaching materials and learning resources as knowledge that students can construct independently, linked to previous knowledge; students seek meaning through knowledge construction [26]. In addition, problem-based learning with the case study method provides an opportunity to be actively involved through solving cases provided in the CBI software [27]. Knowledge emerges through processes of collaboration, social negotiation, and assessment of existing perspectives. Following the basic concepts of the constructivist CBI approach, which are integrated with problem-based learning and case studies [28].

While the case study is in the form of a particular problem explanation, event, or situation, students are assigned to find alternative solutions. This method also can be used to develop critical thinking and find new solutions to a topic that has been solved. This case study encourages problem determination, investigation, and persuasion that must be carried out by students [29]–[31]. Therefore, one of the most important elements of the case study method is the collaborative discussion of the issues involved in the case. Students can identify what they know and what they need to know and understand the case and define the problem to be investigated. By this collaborative discussion, students certainly interact with each other (group mates) in carrying out case study learning steps [32].



(a)



(b)

Fig. 1. Part of coding in developing the constructivist CBI

CBI programming was developed using ActionScript 3.0 (Figure 1). Figure 1 shows part of the ActionScript used in developing a constructivist CBI. In this study, CBI is

software designed to provide students about learning materials and to hone their skills through the software. The software also provided an educational game, then ends with solving cases like a detective game.

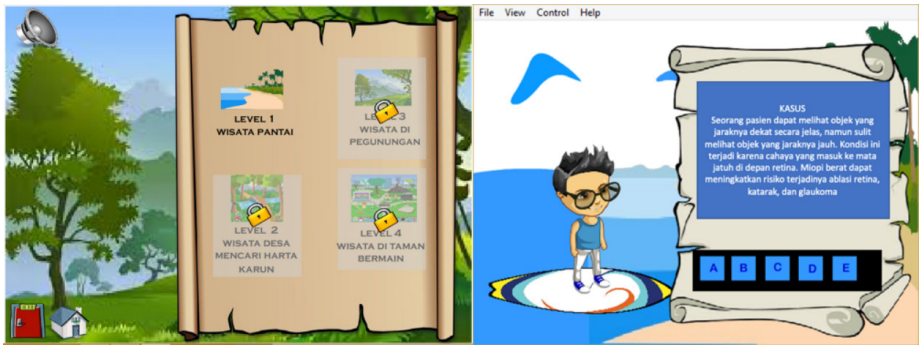


Fig. 2. Constructivist CBI

Figure 2 presents the form of the software used in learning, where students are asked to collect diagnosed cases, gather information, and determine the right solution for the case, thereby constructing their knowledge. Constructivist CBI integrates problem-based learning and case studies as a technique for solving student problems through an in-depth approach and through the stages of observation and research to determine problem-solving [33].

This study aims at determining the effectiveness of the PBL-cflip in reflection clinical learning. There are two groups in this study: the control group, which learns using traditional methods, and the experimental group, which learns using PBL-cflip. Assessment is examined by a pretest and posttest in the both of experimental and the control class [34]. The descriptive data of mean for two groups can be seen in Table 3.

Table 3. Research participants

Variables	Experimental Group (n = 30)		Control Groups (n = 30)	
	Mean Pretest	Mean Posttest	Mean Pretest	Mean Posttest
Problem Solving Skills	47.66	78.83	47.33	61.00
Critical thinking skills	53.80	79.3	53.62	68.5
Communication skills	53.97	82	53.86	66.7
Collaboration skills	44.23	84.70	44.10	67.5

Table 3 provide information on the mean score of pretests on the experimental and control groups were almost the same, which means that students in both groups had the same initial abilities before treatment, it is better for both groups to implement the treatment. Looking closely to the experimental group, the mean score of posttests on problem-solving skills (78.83), critical thinking skills (79.3), communication skills (82) and collaboration skills (84.70) increased compared to the pretest of problem-solving skills (47.66), critical thinking skills (53.80), communication skills (53.97) and

collaboration skills (44.23). However, the mean score of experimental group posttests was higher than to the control group, which means that the PBL-cflip implementation affects students' 4C abilities [35]. With regards to the control group, the mean score of posttests on problem-solving skill (61.00), critical thinking skill (68.5), communication skill (66.7), and collaboration skill (67.5) also increase compared to the mean score of pretest on problem-solving skills (47.33), critical thinking skill (53.62), communication skill (53.86), and collaboration skill (44.10).

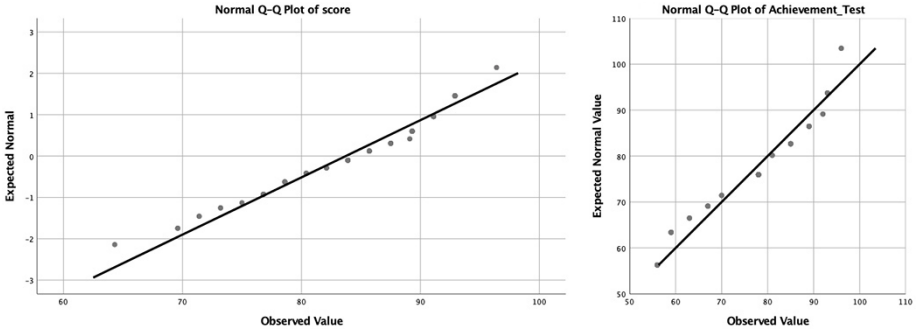


Fig. 3. QQ plots of normality test

Figure 3 showed the information on figure of variables normality test. Overall, the graphic showed that the data distributed normally. The data distribution for problem solving skills (P > 0.05, Z = 1.162), critical thinking skills (P > 0.05, Z = 1.831), communication skills (P > 0.05, Z = 1.752), and collaboration skills (P > 0.05, Z = 1.166) indicate that the data for these four variables is normal [36]. In addition, based on Levene's test, it showed that problem-solving skills (P > 0.05, Levene's statistic = 0.332), critical thinking skills (P > 0.05, Levene's statistic = 1.412), communication skills (P > 0.05, Levene's statistic = 0.952), and collaboration skills (P > 0.05, Levene's statistic = 0.512), which means that data was homogeneous, the data has a significant probability > 0.05. In addition, the Levene statistics show that smaller value, it will be greater homogeneity. It can be concluded that the experimental and control class have the same variance. It means that the data can perform to parametric tests on independent samples t-tests, ANOVA, and gain scores [37].

Table 4. Comparison of posttest scores among groups

Variables	Groups	N	M	Mean Difference	t	df	P
Problem Solving Skills	Experimental Group	30	78.83	17.83	8.891	59	0.000
	Control Group	30	61.00				
Critical Thinking Skills	Experimental Group	30	79.3	10.8	12.031	59	0.001
	Control Group	30	68.5				
Communication Skills	Experimental Group	30	82	15.3	8.724	59	0.000
	Control Group	30	66.7				
Collaboration Skills	Experimental Group	30	84.70	17.2	8.978	59	0.000
	Control Group	30	67.5				

Table 4 provides information on figure of the data analysis results. There is a significant difference in concentration between the control group and the experimental group on problem-solving in skills ($t = 8.891$; $p < 0.05$), critical thinking skills ($t = 12.031$; $p < 0.05$), communication skills ($t = 8.724$; $p < 0.05$) and collaboration skills ($t = 8.978$; $p < 0.05$). Based on the results of the mean difference in problem-solving skills (17.83), critical thinking skills (10.8), communication skills (15.3), and collaboration skills (17.2), due to the value is positive, the experimental group has a higher mean score than to the control group.

The student achievement after the PBL-cflip implementation, the result showed that PBL-cflip was effective in improving student 4C skills in clinical refraction courses. It means that PBL-cflip has an important role in providing learning effectiveness of vocational education. The implementation of flipped-problem based in improving students' critical thinking skills problem-solving abilities [38]–[40].

Table 5. ANOVA test results

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
4Cs skills	Between Groups	5220.863	9	580.096	3.301	.003
	Within Groups	8787.470	50	175.749		
	Total	14008.333	59			

Table 5 reveals the information of ANOVA result on the significant difference between the control and the experimental group in the four skills. ANOVA shows a P-value of 0.03. Thus, at the significant level of $P < 0.05$, which means the null hypothesis (H0) was rejected [41], the conclusion showed that there is a significant difference in the mean score between the control and experimental group on these four skills. This research was supported by previous research that showed the effectiveness of problem-based, CBI, and flipped learning in improving 4C skills, even though there were also some research that showed problem-based and flipped learning do not affect 4C skills together [42]–[45].

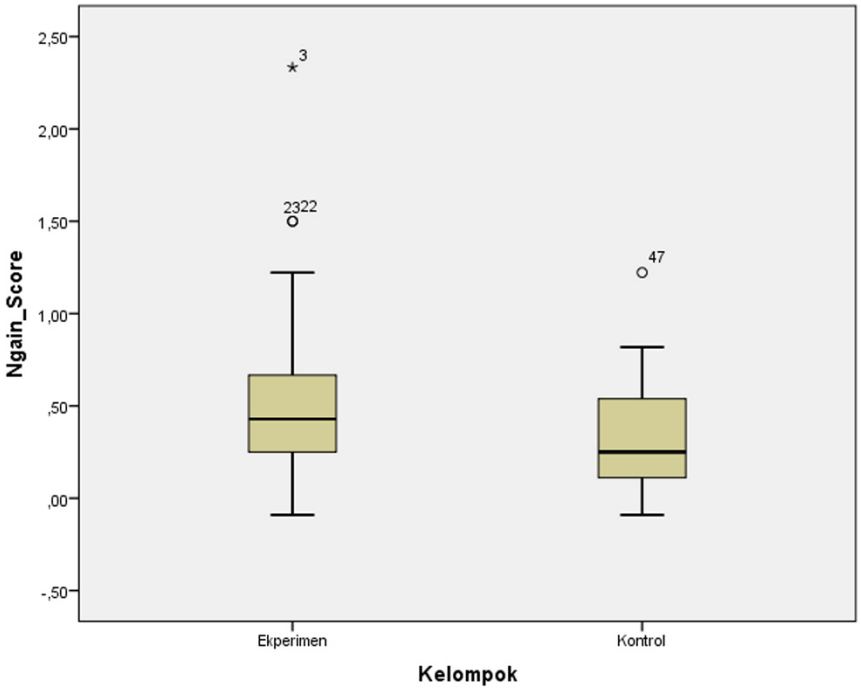


Fig. 4. QQ plots of normality test

Figure 4 provide the information on figure of the N-gain score calculation. Overall, the number showed the experimental score is higher than control score. The N-gain score for the experimental class being 78.83 or 78.83%, which is in the effective category, with a minimum N-gain score of 50 and a maximum of 90, while the N-gain score for the control class being 47.33 or 43.33%, it is the ineffective category, with a minimum N-gain score of 40 and a maximum of 60. It means that the PBL-cflip implementation is effective for improving students' 4Cs abilities in clinical refraction learning [23].

This study has positive impact for the development of learning approaches using PBL-cflip. It more emphasis on vocational education, it can improve students' understanding and skills in critical, creative, communicative, and collaborative thinking. The CBI and problem-based learning that implemented by flipped can improve students' 4C skill and improve student problem solving as well through implementation of CBI and flipped-problem based [33]. The results of this study also are in line with Moulidah [46] finding, it provides information of problem-based, CBI, and flipped learning effectiveness in improving 4C skill. Event though, this research finding contradict with Karabulut finding [39].

Vocational education is an institution that can focus on developing competence and expertise in the vocational field [47]–[51]. Based on the finding, it showed that through implementation of PBL-cflip, it gave freedom for students to develop thinking skills in learning and seek information to solve case in clinical refraction. It is supported by

Ceker and Ozdamil [40], who put forward four theoretical arguments about what is needed in vocational education. First, humans demand work because of a need, so there is a need for activity, freedom, power, social recognition, and pleasure. Second, humans are motivated to work because of three aspects: material, cooperation, and identity (ego); third, the urge to work comes from psychology, safety, belonging, and love, importance, respect, self-esteem, and freedom, wanting information, understanding, love of beauty, and personal self-actualization. Fourth, this is how urgent humans are about the need for work [42], [52], which can also be interpreted as how urgent humans are about the existence of championship education in preparation for work.

As a result, teachers and students assume that PBL-cflip approach motivates, encourages, and supports students to optimally develop all of their potential, whether in cognitive, emotional, or psychomotor aspects, in order to achieve higher self-quality, conscious, systematic, and ongoing orientation effort. Education is essentially a process of maturing the quality of life and a process that frees students from stupidity, incompetence, helplessness, dirty words, dishonesty, and bad thoughts, morals, and beliefs [43].

PBL-cflip is an approach that provide real problems as a context in which students learn critical thinking and problem-solving skills as well as acquire knowledge of Aslan [44]. PBL-cflip can contribute in education and curriculum development system that creates interesting critical thinking techniques as well as important information and skills, put students in the important role of regular problem solvers who are not well organized [44]. PBL-cflip tries to solve problems through several stages of the scientific method, where students can learn knowledge related to these problems. At the same time, students are expected to have problem-solving skills [53]. PBL-cflip addresses improvements in learning implementation, The PBL-cflip able to achieve the competencies expected by the world of work, so they can compete globally. PBL-cflip is proven to be able to make students learn independently, flip, and be able to solve the cases.

4 Conclusion

The flipped PBL-cflip is a learning approach using CBI integrated problem-based learning and the case study method. In clinical reflection courses, there are elements of 4C skills in case solving, namely elements of collaboration, communication, critical thinking, making arguments, drawing conclusions, and creativity. The effectiveness of the PBL-cflip has been measured using on 4C skills. The results prove that PBL-cflip is effective in improving students' 4C skills. The PBL-cflip concept is based on 21st-century learning, which contains various elements to improve skills such as critical thinking, communication, collaboration, and creativity. So, it is hoped that the PBL-cflip will be able to answer future challenges.

PBL-cflip can be used as an effort to improve the quality of learning in clinical refraction courses and at the same time produce graduates who are able to face the demands of skills in the 21st century, especially critical thinking skills, communication, collaboration, and creativity. Besides that, it can be a learning solution that is relevant to the characteristics of students in the digital era (digital natives) and learning trends in the 21st century. This research will contribute to the existence knowledge, especially in

the effectiveness of learning approaches in improving 4C skills. The limitation of this study showed that PBL-cflip is implemented only on thinking skills and not at other skills. So, it can be consideration for similar further research to see the effectiveness of PBL-cflip on other skills such as soft skills and generic skills.

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