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The Effectiveness of New Inquiry-Based Learning (NIBL) for Improving Multiple Higher-Order Thinking Skills (M-HOTS) of Prospective Chemistry Teachers

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Abstract: New Inquiry-Based Learning (NIBL) was developed to improve students' multiple higher-order thinking skills (MHOTS), such as thinking critically, analytically, creatively, and practically (CACP). This study aimed to examine the increase of students' MHOTS ability, their perceptions of the NIBL model, and the contribution of the NIBL model to the learning outcomes. A quasi-experiment of the nonequivalent control group design was implemented in this study. Research subjects were university students majoring in chemistry education and enrolling in the Organic Chemistry course. The experiment and the control groups consisted of 34 and 32 students, respectively. The collected data were analyzed by using t-test and ANCOVA procedures. N-Gain scores were calculated to measure the differences in the increase in learning outcomes. Eta square values measured the contribution of NIBL. The results of this study revealed that there were differences in the learning outcomes of the experiment and control group. The CACP thinking skills and the mastery of organic chemistry concepts of the experiment group increased significantly. The N-Gain scores of practical thinking skills aspect were on medium category, and for critical, analytical, and creative thinking, as well as for mastery of organic chemistry concepts were on high categories. For the control group, the N-Gain scores of all categories were on low or medium categories. The NIBL model effectively improved the prospective chemistry teachers' M-HOTS in terms of CACP thinking skills and contributed significantly to the increase in the students' mastery of organic chemistry concepts.

Keywords: *CACP thinking skills, the effectiveness of NIBL model, students' Multiple-HOTS.*

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Introduction

The 21st century is marked with the increasing complexity of problems of life and challenges on one side and significant accumulation of information on the other side, which sometimes makes the complexity of life more severe. The ability to think critically, analytically, creatively and other forms of higher-order thinking skills to respond to this situation appropriately indicate the existence of high quality of human resources. In the education context, these mental abilities are crucial for the students facing such challenges (Chang, 2000; Che, 2002). There are also fundamental needs to prepare students to be communicative, collaborative, creative, innovative, and to think critically and analytically to solve real-world problems effectively in the global competition era (Cai et al., 2017; Sang et al., 2018; Toheri, 2019; Zhou, 2018; Zivcovic, 2016). These conditions require educators to provide opportunities for students to possess Higher Order Thinking Skills (HOTS) and mastery of needed abilities according to their future professions.

In achieving thinking ability and skills almost certainly, chemistry will play a crucial role, especially in the fields of science and technology (Chang, 2000). Chemical phenomena can be found around us every day, such as in work and daily life, which should be understood by people from the aspects of ontology, epistemology, and axiology (Brown, 2012). Keeping in mind the importance of chemistry in life will improve students' awareness to achieve excellent and correct understandings of the essential chemistry concepts. It is essential for students who study chemistry to get lessons and training for developing their higher-order thinking skills (Santos, 2017). However, according to the results

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of the study of Aktas and Unlu (2012), it was indicated that higher-order thinking skills of university students were only at a medium level and were judged as not yet sufficient.

Demirhan (2014) argued that teachers play an essential role in developing and enhancing students' critical thinking skills. Preparing students to be able to think critically is an essential educational goal in colleges and is a critical issue to be discussed and developed (D'Alessio, 2019; Gojkov, 2015). Many colleges were criticized because of the lack of effort to prepare their students to be able to solve problems and think critically (McCormick, 2015; McLaughlin et al., 2014). Therefore, studies on the development of higher-order thinking skills of students, such as critical and analytical thinking skills are urgently needed (McDonald, 2012; Qing, 2010).

Along with the demands of 21st century life, future learning outcomes should also involve components of critical thinking and creativity (Partnership 21st Century Skills, 2007). Higher Order Thinking Skills are essential for teacher candidates. The graduates of teacher education institutions are supposed to continue improving their HOTS by organizing and implementing teaching-learning activities as practice skills that can further improve HOTS their students in the future. Based on this explanation, there were relationships among critical, analytical, creative, and practice thinking skills that can take place. Sternberg and Grigorenko (2006) analyzed creative thinking by categorizing intelligence into three parts as the focus of the triarchic theory of intelligence. Those are analytical, creative, and practical intelligence. As a group, enriched with the ability of practical thinking skills, these four components of HOTS become the focus of this study, which are necessary abilities to be developed for prospective teachers: Critical, Analytical, Creative, and Practical (CACP) thinking skills.

Teachers, as agents of change, should guide students to develop CACP thinking skills. Future teachers must also be prepared to become teachers who can train their students these skills. Therefore, teachers need thinking skills to help their students to achieve mastery of the skills that are needed either in separated or integrated complex forms. The integration of various thinking skills can be done in the form of practical thinking skills. The essential aspects of practical thinking skills can be represented by applying, using, presenting, and practising (Williams, 2016).

The importance of critical thinking skills has been sufficiently investigated (Atabaki et al., 2017; Demirham & Koklukaya, 2014; Kirmizi et al., 2015; Kivunja, 2014; Kondakci & Aydin, 2013; Murawski, 2014; Qing et al., 2010; Radulovic & Stancic, 2017; Santos, 2017; Tallent & Barnes, 2015). The importance of creative thinking has also been studied at various levels. Some studies were conducted at school level (see for example Akcanca et al., 2019; Senner, 2015; Sriwongchai et al., 2015; Widiana & Jample, 2016) and other studies were conducted at school levels (see, for example, Hong et al., 2013; Kacan, 2015; Mokaram et al., 2011; Oncu, 2016). Analytical thinking should not be separated from critical thinking and creative thinking, because students were encouraged to think critically when analyzing their invention or facing ambiguous situations (McDonald, 2012; Nuangchalerm & Thammasena, 2009; Robins; 2011). The development of analytical thinking skills at the college/university level should also be encouraged (Wendt & Ase, 2015).

Prospective teachers need to be equipped with CACP thinking skills so that in the future, they can teach their students the same skills (Minister of Education and Culture Regulation, 2016). Various studies about critical, analytical, creative, and practical thinking skills have been conducted separately for each thinking skill aspect as well as in the forms of combinations of two or more thinking skills. Critical and creative thinking skills have also been reviewed separately or in combination by several experts (Chang et al., 2015; Mokaram et al., 2011; Oncu, 2016; Sriwongchai et al., 2015; Widiana & Jample, 2016) or the forms of synergy between critical and creative thinking skills (Spuzic, 2016). Toheri et al. (2019) study about improving students' critical and creative thinking skills to secondary school students. Studies on the correlation between critical thinking and problem-solving skills have also been carried out (Kirmizi et al., 2015; Kivunja, 2014). Other studies focused on critical thinking skills in association with metacognitive learning (Gotoh, 2016; Gurcay, 2018), critical thinking with learning styles (Dilekli, 2017), and the relation of critical thinking with Problem Based Learning (PBL) models (Siriwat & Katwibun, 2017; Zhou, 2018). Although these studies focused on the aspects of HOTS and efforts to improve them, the thinking skills were examined individually or in a combination of two aspects of thinking only. No study of the combination of more than two aspects, or multiple higher-order thinking skills (HOTS) has been carried out. Since the thinking skill aspects are interrelated with each other, comprehensive learning strategies are needed to develop multiple-HOTS.

The current research examines an effort for improving comprehensive HOTS or multiple-HOTS, which are integrated, consisting of CACP thinking skills. This study is essential as teachers of the future are required to be able to organize learning that can facilitate their students to reach 21st century learning achievements known as 4Cs; critical, creative, collaborative, and communicative. In this current research, the thinking skills aspects that were involved were CACP thinking skills, while the collaborative and communicative aspects were studied as nurturant effects. Teaching and learning of chemistry are supposed to be conducted with models or approaches that can facilitate students to train themselves to be able to think at the higher level, and questions in the tests should also support the development of HOTS (Fensham, 2013). Therefore, prospective chemistry teachers also need to be prepared in this study by providing learning experiences that can train them HOTS or multiple-HOTS, such as CACP thinking skills. The learning process with a new framework, known as new inquiry-based learning (NIBL) adapted from Pedaste (2015), has been developed for this purpose in this study. Learning experiences obtained with the NIBL model are expected to be useful for improving the students' CACP thinking skills.

Literature Review

Chemistry is central to science. The mastery of basic concepts of chemistry is an essential requirement for students who are studying biology, physics, geology, ecology, and other fields of science. Sufficient knowledge of chemistry is also an essential requirement for human beings living in a modern era. Living in the 21st century, which is increasingly complex, the needs for mastery of intelligence, analytical and creative thinking ability, and other forms of higher-order thinking skills are unavoidable (Chang, 2000). Chemistry exposes the characteristics of general scientific knowledge that are factual, conceptual, procedural, and metacognitive, which can be associated with thinking processes. This way of learning involves higher-order thinking skills. The combination of knowledge dimension and thinking processes can be seen on the matrix, as shown in Figure 1.

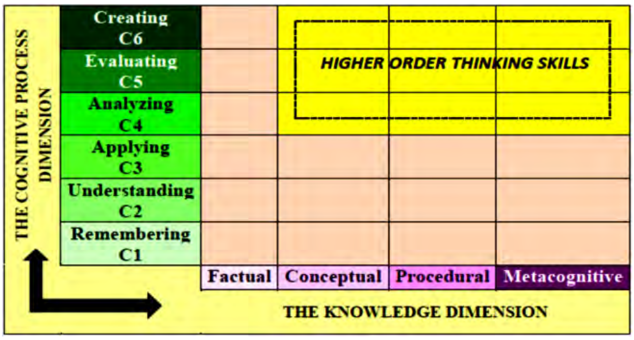

Figure 1. The Combination of Knowledge Dimensions and Thinking Processes (Anderson, 2001; Kemendikbud, 2018)

Figure 1 shows the thinking process dimensions for C1 to C3 in which factual, conceptual, procedural, and metacognitive knowledge dimensions are all at low levels, while for C4 to C6 conceptual knowledge, procedural, and metacognitive dimensions are in Higher Order Thinking Skills (HOTS) categories.

Referring to 21st century learning achievements, students must have the mastery of critical thinking, creative, communicative, and collaborative skills or 4Cs (Partnership 21st Century Skills, 2007). In developing multiple-HOTS, the students needed an appropriate learning model that guides teachers to implement the teaching and learning processes professionally.

Chemistry has high relevance to students' life and involves declarative, procedural, and epistemic knowledge that can be studied through inquiry-based learning strategies (Rahayu, 2017). Therefore it is necessary to train the skills or improve HOTS such as CACP of the teachers so that they are not only as technicians but more than just teaching; they can improve their professionalism in organizing learning and can prepare their students to face 21st century challenges better. Zivcovic (2016) states there is a need to prepare students in a global competition to be more communicative, collaborative, creative, innovative, able to practice critical and analytical thinking, and able to solve problems in real-world effectively.

The Regulation of Minister of Education and Culture of The Republic of Indonesia Number 21 of the year of 2016 contains the core competencies for the senior high school level in the skills domain that are described as follows: *demonstrate the skills of reasoning, processing, and presenting effectively, creatively, productively, critically, independently, collaboratively, communicatively, and solving the real problem.* The competencies in chemistry content for science and mathematics majoring Senior High School students are formulated as follows: *To be able to develop scientific attitudes such as curiosity, logical and analytical thinking, being diligent, tenacious, honest, disciplined, responsible, and caring through chemistry.* Therefore, learning of chemistry should be organized with a model or approach that can train students to think critically and analytically. It means that teachers or prospective teachers with the competence of thinking at higher levels are logically needed.

The ability to choose a way of problem-solving involves analytical thinking. Analytical thinking is defined as developing the capacity to think wisely, differentiate ways to solve problems, data analyze, recall, and use information (Amer, 2009). Chemistry involves not only analytical thinking but also creative thinking. Successful in learning chemistry needs many higher-order thinking skills as support. One of the learning approaches that can be used for developing students' multiple-HOTS is an inquiry learning with a new framework (Pedaste et al., 2015). In this new framework, inquiry-based learning (IBL) begins with an orientation and progresses through conceptualization for investigation, like a cycle of IBL syntax and terminated with a conclusion phase. Discussion phase (including communication and reflection) expectedly will appear at any phase during the phases of IBL and related to other phases as it can occur anytime during the discussion activity or after the cycle of IBL is completed.

According to Sternberg et al. (2012), three mental processes support all creative processes. The three basic mental processes are meta component, performance component, and knowledge acquisition component. Meta component is an administrative process that is used to solve problems, plan what needs to be done, make decisions, and evaluate the results. The performance component shows the direction of the progress of the meta component from the start to result. It is the performance components that are executed, and the results are stored in short term memory, for comparing two concepts and comparing solutions of two tasks. The meta component tells us what is to be done, the performance component actualizes the intended work, and the component of knowledge acquisition is to assess what is learned along the process (Williams, 2016).

Referring to Ionescu (2013), dynamic scientific knowledge development requires teachers to always update their learning content from time to time. Related to the professionality of teachers that can be trained in learning as *performance* development, the syntax of learning has developed following a new framework known as *NIBL,* which includes orientation, conceptualization, investigation, conclusion, and *performance*. These stages are similar to the stages of inquiry syntax-raised by Pedaste et al. (2015). The discussion stage can occur anywhere along with the phases and couple with the performance stage as an accumulation of mastery of HOTS of students; in this case, prospective teacher students.

NIBL learning has proposed some HOTS components. More flexibility has been developed in many studies by linking the NIBL framework with particular high order thinking components (Barab & Squire, 2004). In this case, the investigation can be started in the conceptualization phase in the forms of short cycles between the conceptualization and the investigation phases. After gathering background information, students may return to the conceptualization phase to test the model/theory in mind. The discussion phase may appear in any phase. The performance stage in the NIBL model can be presented as the students' performance that can be outlined in a worksheet or measured by observation on students' presentations, demonstrations, or while doing practical works as a form of practical thinking ability.

The forms of research which have been carried out on critical, analytical, creative, and practical thinking skills were still focusing on the examination of each skill or a combination of just two thinking skills. This current study, on the other hand, was designed to study CACP thinking skills in an integrated design. Learning strategies for improving multiple HOTS (M-HOTS) in an integrated manner was carried out by implementing *NIBL,* which has five phases in its syntax, namely orientation, conceptualization, investigation, conclusions (Pedaste, 2015), and was completed with performance phase. Systematically the relationship of previous research frameworks about HOTS with integrated CACP thinking skills that were studied in this study along with the implementation of NIBL learning is presented in Figure 2.

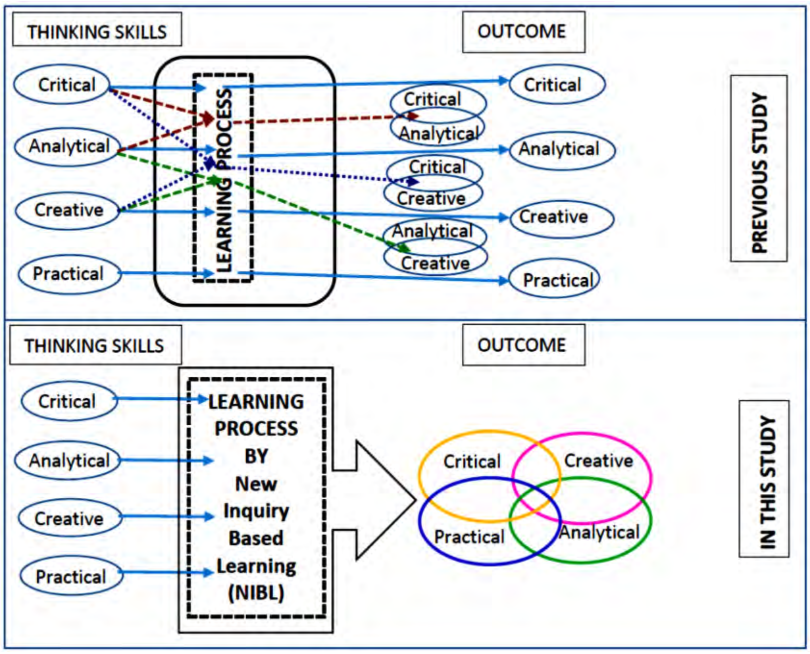

Figure 2. Studies about higher-order thinking skills in separated and integrated designs.

Some studies on higher-order thinking skills such as CACP took it as an integrated entity, M-HOTS. Critical thinking is defined as rational and reflective thinking and focusing on what is believed as accurate and done (Ennis, 2015). According to Paul (1993), critical thinking is a process of intellectual discipline that actively and skillfully conceptualized, implemented, analyzed, synthesized, and evaluated information collected from or generated through observation, reflection, or communication that is believed as a truth and as a guide to action. While analytical thinking is defined as developing the capacity of thinking wisely, compare ways to solve problems, analyze data, recall, and use information (Amer, 2009).

The components of analytical thinking include the ability to compare or analyze elements, relationships, and analyze organization (Anderson et al., 2001; Karthwohl, 2002). Creative thinking is generally defined as mental abilities that involve fluency, flexibility, originality, sensitivity to problems, and views on the relationship with other things or ideas. Creative thinking is also seen as a substantiation of creativity (Alfuqaha & Tobasi, 2015). Creative thinking and problem-solving can be developed through many ways of learning, and creativity is seen as essential for future students' success (Gregory et al., 2013; Plucker, 2015). The development of creativity must be integrated into the education system from pre-school to university (Oncu, 2015). The accumulation of critical thinking skills involves analytical thinking, and the core of creative thinking can be substantiated as practical thinking. According to Sternberg et al. (2012), the critical aspects of intelligence theory are components of practical thinking that interpreted as accurately applying, using, practising, and implementing. Practical teaching means encouraging students to (a) apply, (b) use, (c) practice, (d) implement, (e) work on, and (f) make practical what they know (Sternberg, 2005). The intended practical thinking skills, such as demonstrating how someone uses their knowledge in their life or work, shows how a person can apply his knowledge to solve real problems (Sternberg & Grigorenko, 2000).

Based on the background of the needed or importance to increase multiple HOTS for the next generation and the supporting theories, the NIBL model can be expected to increase the multiple HOTS of prospective chemistry teachers as provisions to improve HOTS of their students in the future.

Methodology

Research Goal

The objectives of this research were: 1) to examine the effectiveness of the NIBL model for improving many higher-order thinking skills (M-HOTS), consisting of CACP thinking skills of prospective chemistry teachers, 2) to examine the perception of prospective chemistry teachers towards the NIBL model for improving CACP thinking skills, and 3) to examine the contribution of the NIBL learning model to the learning achievement of prospective chemistry teachers viewed from certain aspects of the CACP thinking skills and the mastery of (organic) chemistry concepts.

Research Design

This study was carried out using a quasi-experimental of nonequivalent control group design. This design was used because the selection of research subjects did not allow randomization (Tuckman & Harper, 2012). This design was similar to the randomized pretest-posttest control group design for all aspects except randomization. A pretest was given to both experimental and control groups to overcome the potency of bias (Tuckman & Harper, 2012). In the final analysis, the pretest scores were used to correct the posttest scores of the experimental and the control groups. The details of the research design can be seen in Table 1.

Table 1. Details Nonequivalent Control Group Design

Group	Pretest / Type of question		Treatment	Posttest/ Type of question	
Experiment	O_1 (A)	O1(B)		O1(B)	O2(F)
		O1(C)	X	O1(C)	
		O1(D)		O1(D)	
		O1(E)		O1(E)	
Control	O1(A)	O1(B)	Y	O1(B)	O2(F)

Notes:

O1 (A) = pretest is given to the experimental and control groups with the same instrument. This pretest aimed to test the similarity of the two averages at the entry point between the experimental and control groups. The matter used is stoichiometry with O1 (A) instrument.

O1(B) = pretest and posttest tested to the experimental and control groups to test the initial ability of critical, analytical, creative, and practical (CACP) thinking skills, which were general and questions related to the concepts of carbohydrate integrated with the CACP thinking skills.

O1(C) = pretest and posttest tested to the experimental group to test the initial mastery of protein sub- a material with the O1 (C) instrument integrated with CACP thinking skills.

O1(D) = pretest and posttest tested to the experimental group to test the initial mastery of fat sub-material with text questions O1 (D) integrated with CACP thinking skills.

O1(E) = pretest and posttest tested to the experimental group to test the initial mastery of natural products sub-material with O1 (E) instrument integrated with CACP thinking skills.

O2(F) = posttest was given to the experimental and the control groups for all materials (carbohydrates, proteins, fats, and natural products) integrated with CACP thinking skills.

X = treatment given to the experimental group in the form of learning using the NIBL model.

Y = treatment given to the control group in the form of conventional learning in the form of lectures supported by PowerPoint media.

Subject and Data Collection

The research subjects consisted of two classes of prospective teacher students in the Chemistry Education study program who enrolled in organic chemistry courses in the 4th semester. The experimental group consisted of 34 students who were treated with the NIBL learning model, while the control group consisted of 32 students treated with a conventional learning model.

Data collections were carried out for twelve meetings in an organic chemistry course on four topics, namely; carbohydrates, proteins, lipids, and natural products. The implementation of NIBL in this learning was supported by validated NIBL learning set in the forms of the syllabus, lesson plans, worksheets, and test instruments that were developed with the orientation to critical thinking skills referring to Ennis (2011) by limiting to five out of 12 indicators in total namely; (1) asking and answering questions, (2) observing and considering the results of observations, (3) presenting hypotheses and conclusions, (4) determining an action, and (5) interacting with others. Analytical thinking skills referring to the revised Bloom Taxonomy (Karthwohl, 2002) focused on three types of analytical abilities, namely analysis of an element, relationship, and analysis of organizational principles. Creative thinking skills followed the creative thinking skill concept developed by Gilford & Torrance, which contained four characteristics, namely originality, elaborate, fluency, and flexibility (Filsaime, 2008). The components of practical thinking skills followed the critical aspects of practical thinking skills proposed by Sternberg et al. (2012). Practical intelligence was defined as the ability to do well, adapt, and shape in an environment both in formal and informal situations (Sternberg, 2005).

Data collected from the experimental group with the implementation of NIBL in the Organic Chemistry course included students' scores on carbohydrate, protein, fat, and secondary metabolite of natural products. The observation was also done to see the implementation of the syntax of the model. Indicators of students' CACP skills were measured using tests. The development of the test of critical thinking skills followed the indicators stated by Ennis (2011), the test on analytical thinking was developed according to Bloom's taxonomy (Kartwohl, 2001), the test of creative thinking was developed according to Torrance (1980), and practical thinking test was developed by the concept of Sternberg (2012).

Pretests and posttests were used to obtain data on the improvement of CACP thinking skills and the mastery of concepts of organic chemistry for prospective teacher students. Pretest questions were designed by referring to general CACP thinking ability, combined with items that involved CACP thinking skills in integration with organic chemistry concepts. Some of the organic chemistry materials included in pretest questions have been studied, while some have not been studied. Different questions of the same indicators were used in posttest questions. This variation was done with the consideration that the treatment with NIBL learning in this study aimed to improve M-HOTS skills. If the same pretest and posttest questions were used, there was a possibility that the shift of students' thinking ability from lower to higher levels could not be identified, as the students may just memorize the answers to the pretest.

The experimental group was not only given the pretest and posttest related to the mastery of the concepts of organic chemistry that were the same as those given to the control group, but their progress of the improvement of CACP thinking skills was also measured. These were done to see the progress of the students' CACP thinking skills at a specific time integrated into each topic. The tests used indicators of the same learning outcomes of pretest and posttest. A posttest was also delivered to students at the end of each topic completed.

All instruments included observation sheets on the implementation of NIBL and student activity and questionnaires that have content validated by three validators. Content validity of test items determined by using inter-rater validity to measure the percentage of agreement (PA) between validators. Based on the statistic test by using the Cohen's Kappa coefficient, all of the items test obtained percentage of agreement > 0.80 in the high category, according to Morgan et al. (2011) stated that consistency with Kappa ≥ 0.70 on high category. Questionnaires to collect data of NIBL implementation used Likert scale which five options were: 1=strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

Construct validity tests for learning outcomes were validated and tested for reliability using statistical procedures. Based on the results of the trial that had been conducted and its analysis from 35 items for pretest, 31 declares validly, and four items need revision for the language aspect. Meanwhile, from 48 items for the posttest, seven items need revision for the language aspect.

Based on the results of the construct validity test, the reliability was determined by the Cronbach Alpha coefficient, for pretest got α = 0.87 and α = 0.89 for posttest items. Then complete reliability (R) calculated by Spearman-Brown formula (Fraenkel et al., 2012). Reliability of all pretest items 0.93 and all of the posttest items 0.94, so both instruments test were reliable.

Analyzing of Data

Analysis of data was done using statistical tests offered in the SPSS program. T-tests were conducted to find out the similarity of the two averages between the control and the experimental groups at the entry point of treatment and to find out the difference in the pretest and posttest scores, as well as for the scores of progress from pretests to posttests. ANCOVA was implemented to examine the difference between the achievements of the experimental and control groups. Eta squared values were then measured to determine the contribution of the NIBL model to the improvement of learning achievements. N-Gain scores were also carried out to determine the increase in student learning outcomes of the experimental and control groups. Before conducting all measurements, normality and homogeneity of pretest and posttest data were applied.

Finding / Results

The similarity of two pretest results

This pretest was intended to compare the initial cognitive ability between the control and the experimental groups. The pretest data of both experiment class (p = 1.208) and control class (p = 0.777) distributed normally and homogeneous (p = 0.993). While, the posttest data of both experiment class (p = 0.573) and control class (p = 0.512) distributed normally also and homogeneous (p = 0.207). A t-test was carried out on two averages of pretest scores of the experimental and control groups. The results of the test are presented in Table 2.

Table 2. The results of t-test on the averages of pretest scores of experiment and control groups

Test Groups	N	Mean	SD	Value of t	Significance	Criteria	Information
Experiment Class	34	61.647	1.516	0.726	0.473	Sig. > 0.05	No difference
Control Class	32	64.250	1.293				

Based on the results of the t-test above, it can be stated that there was no significant difference in the initial ability of the experimental and the control groups.

The Implementation of NIBL Model for Improving CACP Thinking Skills

The quality of the implementation of the NIBL learning model to improve CACP thinking skills in the classes studying organic chemistry topics of carbohydrate, protein, lipid, and natural product topics is presented in Figure 3.

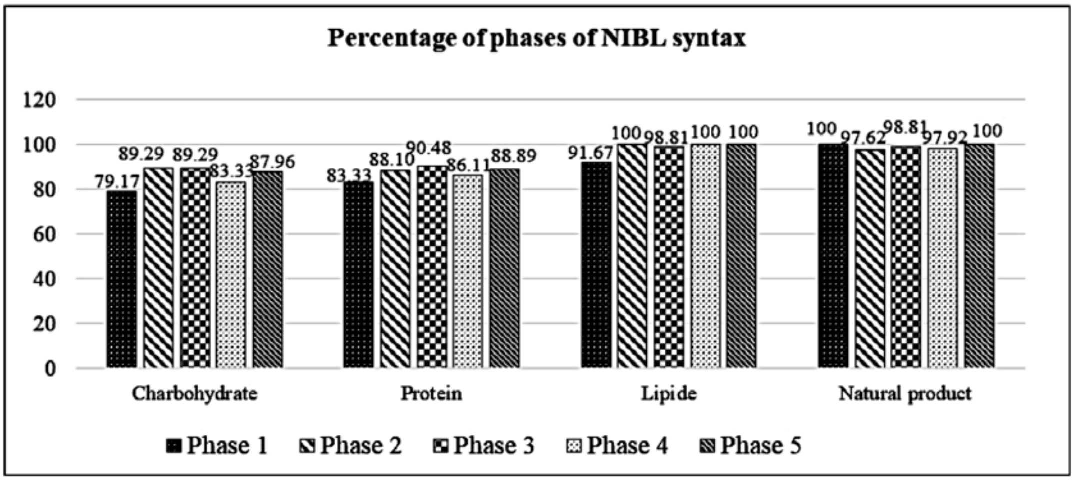

Figure 3. The Implementation of NIBL Syntax in Four Organic Chemistry Topics of Carbohydrate, Protein, Lipid, and Natural Product

Figure 3 shows the implementation of NIBL syntax from phase one to phase five. It can be seen that the model could be implemented with above 75%, which were in good and very good categories. This result indicates that NIBL was a feasible and practicable model. The observation of student activities was also done during the learning process and in the final phase. The performance phase was also carried out in good and very good categories and increased from 87.96% in the first topic to 100% in the fourth topic. Student activities in the performance phase in the NIBL model were further observed to measure the quality of student performance.

Student Activities in the Performance Phase in Learning with NIBL Model on Organic Chemistry Materials

The performance phase of the NIBL model was further observed to know the accumulation of many aspects of CACP thinking skills. Observations on this performance phase were conducted in learning with the NIBL model on four topics of organic chemistry, namely carbohydrates, proteins, lipids, and natural products. The following tables show the results of the observations of the students' activities in the performance phase on the topic of carbohydrate as the first topic to the natural product as the final topic to know the development of the students' achievement progress. The observation data at the performance phase of each group of students can be seen in Tables 3 and 4.

Table 3. Data of Student Activities on Performance Phase in NIBL on Topic of Carbohydrate

No.	Group	Group Average Score									Category
		Aspects Observed								Percentage	
		A	B	C	D	E	F	G	H	(%)	
1	I	3.92	3.83	3.58	3.67	3.83	4.17	4.67	4.00	79.17	S
2	II	4.50	3.42	3.92	3.67	4.25	4.08	4.00	5.00	82.08	VS
3	III	4.60	3.47	3.80	4.07	4.13	3.60	3.00	4.67	78.33	S
4	IV	3.75	3.50	3.75	3.58	3.92	4.00	4.33	4.33	77.92	S
5	V	3.67	3.50	3.67	3.33	3.83	3.67	3.67	4.33	74.17	S
6	VI	3.67	3.50	3.33	3.42	3.58	3.17	4.50	4.00	72.92	S
7	VII	3.47	3.47	3.47	3.47	3.53	4.00	4.00	4.33	75.21	S
8	VIII	3.58	3.58	3.33	3.42	3.42	4.00	4.00	4.00	73.33	S
	Total	**3.89**	**3.53**	**3.61**	**3.58**	**3.81**	**3.84**	**4.02**	**4.33**	**76.27**	S

Information:
VS = Very Satisfying, S = Satisfying
Aspects observed:
A: Participation and communication skills
B: Discussion and answering question skills (critical, analytical, creative thinking)
C: Skills to explain the knowledge gained through NIBL
D: Skills to explain NIBL learning design
E: Mastery of concepts learned
F: Creativity in the use of media in performance (creative and practical thinking)
G: Creativity in linking learning experience with future assignments (analytical and creative thinking)
H: Playing a role in practicing knowledge with performance (practical thinking)

Table 3 shows that student activities on the performance phase on carbohydrate material in initial was on a very satisfying category for one group only and satisfying for the other groups. Their progress can also see students' activities in the performance phase in the last material of natural products presented in Table 4.

Table 4. Data of Student Activities on Performance Phase in NIBL of Natural Product Topic

No.	Group	Average score of three observers									Category
		The observed aspect								Percentage	
		A	B	C	D	E	F	G	H	(%)	
1	I	4.00	3.67	4.17	3.92	4.17	4.33	3.00	4.75	80.00	VS
2	II	4.56	3.56	4.67	4.33	4.67	4.89	4.22	4.33	88.06	VS
3	III	3.93	3.93	3.93	3.33	4.20	5.00	4.00	4.27	80.63	VS
4	IV	4.00	4.00	4.83	4.00	4.00	4.67	4.00	4.67	85.42	VS
5	V	4.83	4.42	4.50	4.33	4.33	4.33	4.67	4.58	90.00	VS
6	VI	3.92	3.00	3.50	4.00	3.58	5.00	5.00	4.67	81.67	VS
7	VI	4.20	3.67	4.00	4.00	4.27	4.67	4.33	5.00	85.63	VS
8	VIII	4.33	4.11	4.11	4.00	4.33	4.33	4.67	5.00	87.22	VS
Total		4.22	3.80	4.21	3.99	4.19	4.65	4.24	4.66	84.83	VS

Notes:
VS = Very Satisfying, S = Satisfying
Aspects observed:
A: Participation and communication skills
B: Discussion and answer question skills (critical, analytical, creative thinking)
C: Skills to explain the knowledge gained through NIBL
D: Skills to explain NIBL learning design
E: Mastery of concepts learned
F: Creativity in the use of media in performance (creative and practical thinking)
G: Creativity in linking learning experience with future assignments (analytical and creative thinking)
H: Playing a role in practicing knowledge with performance (practical thinking)

Table 4 shows that student activities in the performance phase of the last topic of organic chemistry lectures in a very satisfying category for all groups.

Students' Perception of the Implementation of NIBL Model of Learning

The students' responses collected by questionnaires were given at the end of learning after the experimental group finished the NIBL sessions on four topics, namely carbohydrate, protein, lipid, and natural product. Students' responses presented in Table 5.

Table 5. Student Perception Data on the Implementation of NIBL Learning in Organic Chemistry Lectures

NO.	Statements	Student of responses (%)				
		1	2	3	4	5
1	This learning activity provides new experiences	0	3.12	6.25	43.75	46.87
2	This learning process makes me more concentrated on learning.	0	3.12	18.75	59.37	18.75
3	This learning process can train critical thinking	0	3.12	3.12	53.12	40.62
4	This learning process trains analytical thinking	0	0	12.9	41.94	45.16
5	This learning process trains creative thinking	0	3.12	15.62	46.87	34.37
6	This learning experience trains to think practically	0	3.12	12.5	34.37	50.00
7	The stages of learning provide opportunities for students to demonstrate better performance	0	3.12	9.37	37.5	50.00
8	This process of learning makes it **less comfortable**	12.90	59.87	17.75	6.25	3.23
9	The model provides more learning opportunities	3.12	3.12	12.5	50.00	34.37
10	This learning experience is fun and challenging	0	3.12	15.63	53.13	28.12
11	This experience is very beneficial	0	3.12	21.87	37.50	37.50
12	This learning model **should not** be applied	12.90	61.29	19.35	3.23	3.23
13	This learning can be done well	0	6.25	12.5	53.12	31.25
14	This learning is perfect to be applied in learning other topics of chemistry and other fields of study	0	6.25	12.5	46.87	34.37
15	This learning needs to be applied by my groups when they become teachers	0	3.12	12.50	50.00	34.37
16	Learning like this is essential to be applied even though it takes time	0	6.25	15.62	56.25	21.88
17	This learning is very beneficial and adds insight for students	0	0	6.25	46.87	46.87

Note: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 5 shows that students' responses were predominantly positive in almost all aspects of the NIBL model, with a total of agree and strongly agree categories higher than 75%. That remaining 25% were neutral or disagree responses. The CACP thinking skill aspects also received dominantly positive responses with agree and strongly agree responses. The details were as follows: critical thinking, 93.74%, analytical thinking, 87.10%, creative thinking, 81.24%, and practical thinking, 84.37%. Based on the data shown in Table 5, it can be stated that the implementation of the NIBL learning model to improve CACP thinking skills was perceived as positive by the students.

Pretest and Posttest Data of CACP Thinking Skills and The Mastery of Organic Chemistry Concepts of Experimental and Control Groups

The tests were tested to the control and experimental groups, and a comparison of the means of pretest and posttest scores was presented for each aspect of learning achievement of the CACP thinking skills and the mastery of organic chemistry concepts, as shown in Figure 4.

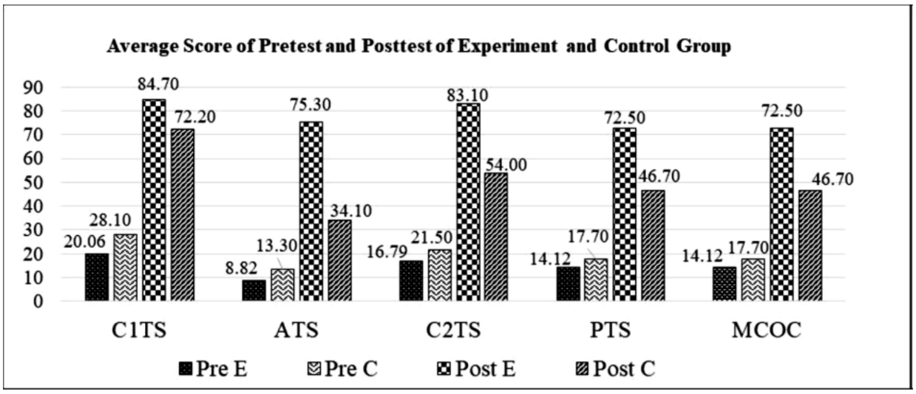

Figure 4. Diagram of Pretest and Posttest Value of Experiment (E) and Control (C) Group

Notes:
C_1TS = Critical Thinking Skills, ATS = Analytical Thinking Skills,
C_2TS = Creative Thinking Skills PTS = Practical Thinking Skills
MCOC = Mastery Concepts of Organic Chemistry

Figure 4 shows that the means of pretest scores of the experimental group in the aspects of C_1TS, ATS, C_2TS, and PTS were slightly lower than those of the control group. The comparisons are as follows: 20.06 to 28.10; 8.82 to 13.3; 16.79 to 21.50; 14.12 to 17.70; while in the aspect of the mastery of concepts the pretest mean score of the experimental group was slightly higher at 14.71 to 11.30. The posttest mean scores after learning using NIBL in the experimental group increased significantly for the experimental group in all aspects, whereas in the control group increased in the C_1TS aspect only. For the other aspects such as ATS, C_2TS, and MCOC mean scores of the experimental group increased higher than those of the control group. This result indicated that the NIBL model was effective for improving multiple-higher order thinking skills/M-HOTS, namely CACP. N-Gain scores from the pretests to posttests were calculated for the experimental and control groups.

In line with the objective of the study, further analyses were done about the effectiveness of the NIBL model for improving students' critical, analytical, creative, and practical thinking abilities.

N-Gain scores of CACP Thinking Skill Tests and Students' Understanding of Organic Chemistry Concepts of Experimental and Control Groups

The improvement of the experimental and control group students' test scores after completing the learning processes in organic chemistry, measured in N-gain scores, can be seen in Figure 5.

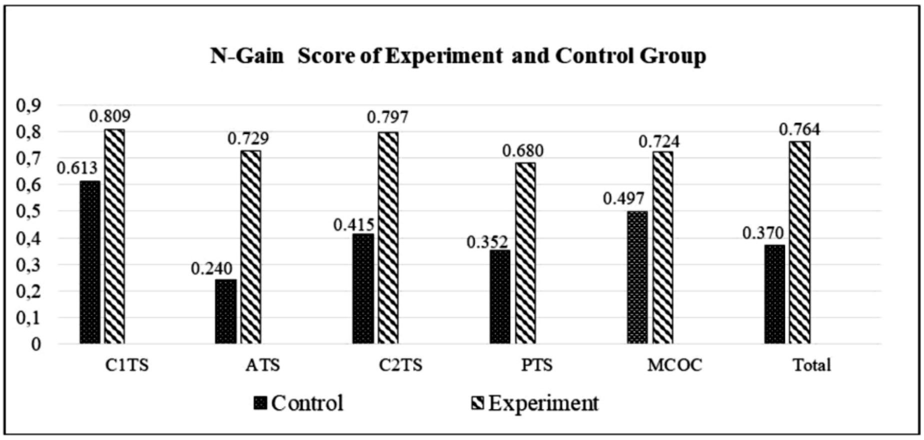

Figure 5. Diagram of N-Gain Score Average of CACP Thinking Skills of Control and Experiment Group

Note:
C_1TS = Critical Thinking Skills C_2TS = Creative Thinking Skills
ATS = Analytical Thinking Skills PTS = Practical Thinking Skills
MCOC= Concept Mastery of Organic Chemistry

The averages of N-Gain scores of the control and experimental groups shown in Figure 5 indicate that the CACP thinking skills of the control group were mostly in the medium category for critical, creative, and practical skills, while for analytical thinking skill aspect and the mastery of organic chemistry concepts were in low categories. Meanwhile, for the experimental group, the N-Gain scores on CACP thinking skills, as well as for mastery of concepts, were in high categories, so as for practical thinking skills. The categorization criteria for N-Gain score values were (<g>)> 0.7 = high category; 0.7 <(<g>)> 0.3 = moderate category and (<g>) <0.3 = low category (Hake, 1998).

Figure 5 shows that the mean scores of pretests and posttests of the experimental group were higher than those of the control group. To further assess the differences of these scores, ANCOVA tests were performed on the scores of pretests and posttests. The control group consisted of 32 students treated with a conventional learning model, while the experimental group consisted of 34 students treated with the NIBL learning model. The posttest scores were taken as the dependent variable scores, while pretest scores were taken as the covariates.

Contribution of the NIBL Model to the Improvement of Learning Achievement

In addition to the analysis of the differences between the experimental and control groups' test scores, analysis to find out how much the NIBL model contributed to students' learning outcomes was also conducted. The contribution of the NIBL model to student learning outcomes can be seen from the effect size in the form of partial eta squared values, as shown in Table 6. The partial eta squared value shows the proportion of the treatment relationship, in this case, the NIBL learning model to different groups, e.g., the experimental and control groups (Leech et al., 2004).

Table 6. Test Results of ANCOVA Pretest and Posttest Control and Experiment Group

No.	Aspect of Thinking	Group	*Mean*	Deviation Standard	F	Significance	Partial Eta Square	Category*
1	Total aspect	E	78.197	6.843	82.928	0.000	0.725	High
		C	49.353	6.662				
2	Critical	E	11.294	1.111	16.038	0.000	0.337	Moderate
		C	9.813	1.139				
3	Analysis	E	25.098	2.569	42.600	0.000	0.575	High
		C	11.042	2.488				
4	Creative	E	17.726	2.723	32.157	0.000	0.505	High
		C	11.582	2.286				
5	Practical	E	7.255	1.371	27.747	0.000	0.468	High
		C	4.646	0.903				
6	Material	E	16.823	2.059	22.427	0.000	0.416	High
		C	12.272	2.004				

*Category *: Low (0.10 ≤ x < 0.25); Moderate (0.25 ≤ x<40); High (≥ 0.40) (Cohen, 1988, p. 390)*
E: Experiment Group
C: Control Group

Table 6 shows that the students who learned with the NIBL model yielded higher learning outcomes in all aspects of the mastery of the concepts and showed significant differences from the control group students (p <0.05). The mean values of the groups were compared to find out which group is better than another. The experiment group with 34 students showed a higher average learning achievement ($\overline{X}$ = 78.19) than the control group, which consisted of 32 students ($\overline{X}$ = 49.35) for the whole aspects. Described in detail, the experiment group consistently showed mean values that were higher than those of the control group. The comparisons were as follows 11.29 to 9.81 for critical thinking skills; 25.10 to 11.04 for analytical thinking skills; 17.726 to 11.582 for creative thinking skills; 7.255 to 4.646 for practical thinking skills; and 16.823 to 12.272 for concept mastery.

Discussion

Description of the Effectiveness of NIBL

The effectiveness of NIBL for improving the multiple HOTS of prospective chemistry teacher students can be seen by the feasibility and practicability of this model in the implementation at organic chemistry course. All of the syntaxes can be done from the first to the final phase. The performance phase, as an extended of IBL model by Pedaste et al. (2015), was also carried out in good and very good categories. Students' responses to the implementation of NIBL stated that the NIBL learning model to improve CACP thinking skills was perceived as positive responses. The effectiveness of NIBL, also can be indicated by N-Gain scores of the experimental group, on CACP thinking skills as well as for mastery of concepts, were in high categories, so as for practical thinking skills. The effectiveness of NIBL also indicated by improving the CACP thinking skills of students. In line with Soufi and See (2019) state that learning critical thinking, in general, can increase students critical thinking, as well as creative thinking skills, can be improved by training programs or learning models (Lucchiari, 2019; Onchu, 2016; Sriwongchai, 2015; Vally, 2019) such as NIBL model.

Contribution of the NIBL Model

NIBL model, in general, has a significant contribution to the students' learning outcomes, as shown by eta squared value of 0.725 for the total aspects (see. Table 6). The contribution of the NIBL model in improving each aspect of learning was as follows: critical thinking skills yielded an eta square value of 0.337, on medium category; 0.575 for analytical; 0.505 for creative, 0.468 for practical thinking, and 0.416 concept mastery which was all in the high categories. Almost all aspects contributed to the improvement of students' achievement in high categories, except critical, which contributed to the medium category. This result probably can be explained as follows, the students' critical thinking ability had been initially higher than the other thinking skills so that the contribution of the NIBL model in improving the students' learning achievement in critical thinking was limited. Meanwhile, the contribution of the NIBL model to the students' learning outcomes, based on partial eta squared values as presented in Table 6, was in general high (≥ 0.40) as also indicated by the eta squared value of 0.725. The contribution of each aspect of CACP thinking skills in supporting total learning outcomes in each material can be seen in Figure 6.

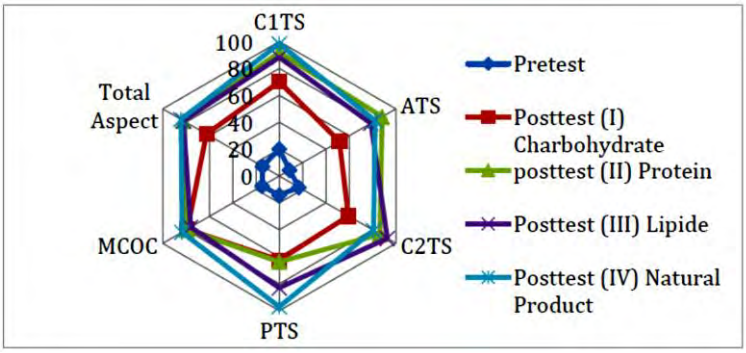

Figure 6. The Pattern of NIBL Contribution to Improve CACP Thinking Skills in Organic Chemistry Course

Note:
C1TS = Critical Thinking Skills
PTS = Practical Thinking Skills
ATS = Analytical Thinking Skills
MCOC = Mastery of Concepts of Organic Chemistry
C2TS = Creative Thinking Skills

The pattern of the contribution of NIBL and CACP thinking skill aspects in supporting the progress of learning achievement in Organic Chemistry, as shown in Figure 6, were generally positive. As a starting point, the pretest values indicated the initial condition of the students, which showed critical thinking skills in the highest or at the outermost position of the curve compared to the other aspects. They increased significantly in the posttest, although the increase was not yet optimal. The highest contribution occurred in the aspect of concept mastery, while for the other aspects, the contributions were relatively lower. This result is typical that students' scores of concept achievement increase after the learning process. In posttest II the highest average score was achieved in the critical thinking aspect, while the lowest score was in practical thinking skill. Posttest III showed relatively balanced learning achievements in various aspects, while in posttest IV contributions to critical thinking and practical thinking aspects, were the highest.

An interesting thing happened in the increase of learning achievement in terms of the mastery of concepts. The increase in concept mastery was consistently shown from the pretest to posttest sessions. For material I a significant difference was already shown with an average that passed the minimum score of > 75. In posttests, II, III, and IV, the average values of > 75 were achieved continuously, although a stagnant condition and even a slight decrease happened in posttest III. In detail, the development of posttest scores from posttests I to IV was 78.82; 79.41; 75.98; and 83.53, respectively. For the aspects of CACP thinking skills, the increase was gradual until it reached the maximum. This result shows that students were more familiar with concepts mastery that involve cognitive aspects of memorizing (C1) and understanding (C2) in line with Bloom's Taxonomy (Anderson, 2001). To improve the CACP thinking skills of prospective teacher students, a treatment such as training through a particular learning strategy, i.e., NIBL, was needed.

Another important finding showed that some aspects of HOTS such as CACP as multiple-HOTS could be achieved through an integrated implementation of the NIBL model, which has a syntax that consists of five phases, e.g., orientation, conceptualization, investigation, conclusion, and performance. Based on these syntaxes of NIBL learning model can contribute to increasing the CACP thinking skills of the students. The integration of the four aspects of CACP thinking skills that can be achieved by learning with the NIBL model is illustrated in Figure 7.

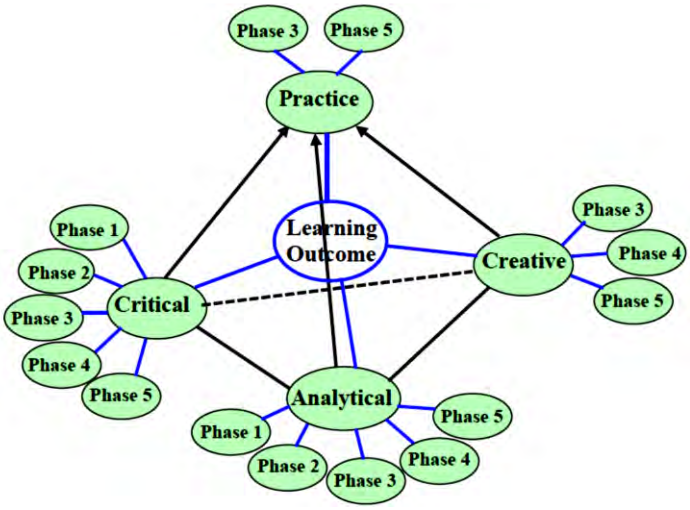

Figure 7. The Integrated impacts of critical, analytical, creative, and practice (CACP) thinking skills on the achievement learning outcome by NIBL Model

Note:
Syntax of NIBL:
Phase 1 = Orientation, Phase 3 = Investigation,
Phase 2 = Conceptualization, Phase 4 = Conclusion,
Phase 5 = Performance

As shown in Figure 7, a relationship exists between critical, analytical, and creative thinking and is realized in the form of practical thinking. The core of creative thinking skills is critical thinking (Zhou, 2018), which also involves analytical thinking (Paul, 1993). Students are encouraged to think critically when analyzing (McDonald, 2012; Nuangchalerm & Thammasena, 2009; Robins; 2011). Critical thinking also synergizes with creative thinking (Chang, 2015; Spuzic, 2016). The critical thinking component, which involves analytical, and becomes the core of creative thinking, can be performed in the form of practical intelligence (Sterenberg, 2012). In turn, the actualization of this in the form of knowledge acquisition strengthens what the students learned during the process by doing actions (Williams, 2016). In the NIBL syntax, critical and analytical thinking skills are involved in all phases, creative thinking skills in phases 3, 4, and 5, while practical thinking in phases 3 and 5. The phase in the syntax of NIBL Model similar to a learning model 5P (persuasion, planning, production, and presentation) can be improved critical thinking skills significantly (Srikoon, 2018)

Conclusion

The implementation of the New Inquiry-Based Learning (NIBL) model in the organic chemistry course improved students' multiple Higher-order thinking skills. The students gained high scores in each aspect of critical, analytical, creative thinking skills, and mastery of concepts (between 0.724 - 0.809), although they gained medium scores in the aspect of practical thinking skills. The average of N-Gain scores of all achievement was 0.680. The differences in the learning outcomes of experimental and control groups were also significant ($p < 0.05$) for all aspects. Students' perceptions of the implementation of the NIBL model in organic chemistry related to the efforts for improving CACP thinking skills were positive. The students stated that the implementation of the model was a fun, challenging, made them feel comfortable. They agreed that the NIBL model might be applied in regular courses. The majority of students also showed positive responses to the choices of CACP thinking skills to be developed. In general, the NIBL model has given a significant contribution to the improvement of students' CACP thinking skills, as well as to the mastery of (organic) chemistry concepts for prospective teacher students so that it can positively support future chemistry education.

Suggestions

There are some suggestions that the NIBL model can be used as an alternative learning strategy, especially for students of Teacher Training Institutions (LPTKs). It is expected the LPTKs will be able to develop and organize learning for their students to have critical, analytical, creative, and practical (CACP) thinking skills, to meet the demands of the 21st century education.

Based on the results of this study, the main multiple HOTS focus on CACP thinking skill only. So, there was a suggestion to study other skills such as communicative and collaborative skills for the future by using the NIBL model. Implementation of the NIBL model needs proper planning and suitable with the curricula, both integrated or single course between theory and practice. This condition as an opportunity to compare for the next research.

The syntax of NIBL model consisting of orientation, conceptualization, investigation, conclusion and performance phases can be applied to a secondary school level or lower, with notes adjusted to the conditions of students both in terms of age and cognitive development by gradually starting with guided inquiry towards free inquiry or scaffolding.

Limitations

This study implemented the NIBL model using four topics only, such as carbohydrates, proteins, lipids, and natural products. The topics have similar characteristics, and for different characteristics, topics of chemistry have not been studied yet. The NIBL model requires more students´ motivation to maintain their engagement during the learning process from the beginning to the end, to achieve maximum goals.

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