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Inquiry Learning Model in Chemistry Education: A Systematic Literature Review

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Abstract: Currently in the 21st century, students are required to master various abilities and thinking skills. Students' abilities do not develop well with learning that only focuses on convergent thinking training. As a result, students have difficulty in developing and improving their ability to master the learning material. Therefore, it is necessary to have an appropriate learning model to improve students' abilities. Based on this, one of the alternative learning models that can improve students' abilities is the Inquiry Learning model. This article aims to provide an overview of the application of the Inquiry Learning model to the achievement of learning objectives in chemistry so that it can improve students' abilities. The method used is a systematic literature review from a literature review with relevant and reputable sources during the period 2017 to 2021. The results show that the inquiry learning model was able to improve students' ability to learn chemistry.

Keywords: chemistry, critical thinking, inquiry learning model.

Abstrak: *Saat ini pada abad 21 siswa dituntut untuk menguasai berbagai kemampuan dan keterampilan berpikir. Kemampuan siswa tidak berkembang baik dengan pembelajaran yang hanya menitikberatkan pada pelatihan berpikir konvergen. Akibatnya siswa mengalami kesulitan dalam mengembangkan dan meningkatkan kemampuan untuk menguasai materi pembelajaran. Oleh karena itu, perlu adanya model pembelajaran yang tepat untuk meningkatkan kemampuan siswa. Berdasarkan hal tersebut, salah satu model pembelajaran alternatif yang dapat meningkatkan kemampuan siswa adalah model Inquiry Learning. Artikel ini bertujuan memberikan gambaran penerapan model Inquiry Learning terhadap ketercapaian tujuan pembelajaran pada materi kimia sehingga dapat meningkatkan kemampuan siswa. Metode yang digunakan systematic literature review dari kajian literatur dengan sumber yang relevan dan tereputasi selama kurun waktu 2017 sampai 2021. Hasil penelitian menunjukkan model pembelajaran inkuiri mampu meningkatkan kemampuan siswa terhadap pembelajaran kimia.*

Kata kunci: *kimia, berpikir kritis, model pembelajaran inkuiri.*

▪ INTRODUCTION

In the traditional learning method, the interaction between teacher and students is limited. The learning process only focuses on the teacher; thus, it does not facilitate the development of students' thinking abilities (Vishnumolakala, 2017; Pitukpong, 2018). The student's thinking ability is not developed well with the learning that only emphasizes the convergent thinking training without giving the problem that students should face (Perdana et al., 2020). Consequently, the students experience difficulty in developing their thinking ability, resulting in this limitation requires an appropriate learning model to improve the student's ability to master the learning lessons. The learning method refers to the learning pattern plan arranged systematically to achieve the learning goal, and class & tutorial management to determine the material or learning

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equipment so that the students are convenient in understanding a lesson (Suprijono, 2013; Arends, 1997; Trianto, 2007).

The inquiry-based learning encourages the students to find the answer to the problem faced by students in the class themselves. According to Bunterm et al. (2014), inquiry-based learning is student-centered learning that encourages the student's participation in the practice used to build scientific knowledge to achieve the desired learning goal (learning outcome). In inquiry learning, the students actively participated in finding the solution to a problem faced in the class (Zuiker & Whitaker, 2014). The solution found by the students is built up from previous knowledge with newly obtained information so that the students can think more critically to find the answer to a question in the learning process.

One alternative solution to improve student's thinking ability is implementing the inquiry learning model. The inquiry model is often mentioned as the investigation model because it allows the students to dig knowledge by deep exploration of a problem and then look for the answer. Roestiyah (2001) stated that an inquiry learning base is a constructivist activity involving observation process conducted by the scientific method. The inquiry learning model requires the student's active role in learning by themselves through mental process of formulating the problem, hypothesizing, experimenting, collecting information, and drawing a conclusion (Roestiyah, 2001; Nalan et al., 2017; Aisyah, 2016). The advantage of inquiry learning is that it can be implemented for chemistry material that has experiment or non-experiment based.

This review study aims to describe the Inquiry Learning model implementation toward the learning goal's achievement on the chemistry material that can improve the student's ability through Inquiry Learning model or strategy. Based on this matter, it is essential to know the influence of inquiry learning model toward the student's ability improvement in the learning process. The inquiry learning strategy can be used to train the student's thinking ability in solving a problem. The writer conducts a review literature analysis to discover and provide a description of Inquiry Learning model implementation toward the learning goal's achievement on the chemistry material and to know the effective inquiry learning strategy implementation on the chemistry learning. The research problems obtained are:

1. What is the influence of the inquiry-based learning model on the chemistry learning goal's achievement?
2. How is the syntax of inquiry-based learning model effective in improving the researched variables?

▪ METHOD

This research uses a systematic literature review for the data collection. The articles in this systematic literature review are analyzed by searching the online article database, namely ERIC and Google Scholar. The keywords used are Inquiry Learning in Chemistry, Inquiry Lab in Chemistry, and Inquiry Learning Model. Then, conducting an article search by mapping. The article mapping process can be seen in Picture 1. The article mapping is limited from 2017 to 2021 (the last five years), with the criteria of a reputable journal article indexed by Scopus (Q1-Q3) and SINTA. The research result from these two online article databases is 517 articles; consisting of 287 articles from ERIC and 230 articles from Google Scholar. The result of the article search in the

database source resulted 517 articles that were selected then based on: 1) learning model, 2) research type, 3) dependent-independent variable, 4) learning model syntax, and 5) research plan. Furthermore, from these 517 articles, 71 articles are found with the relevant inquiry learning in chemistry keyword, and then select the title and abstract. After analyzing the abstract and full paper, it turns out that only ten articles are relevant to the topic. The result of article selection can be seen in the Table 1.

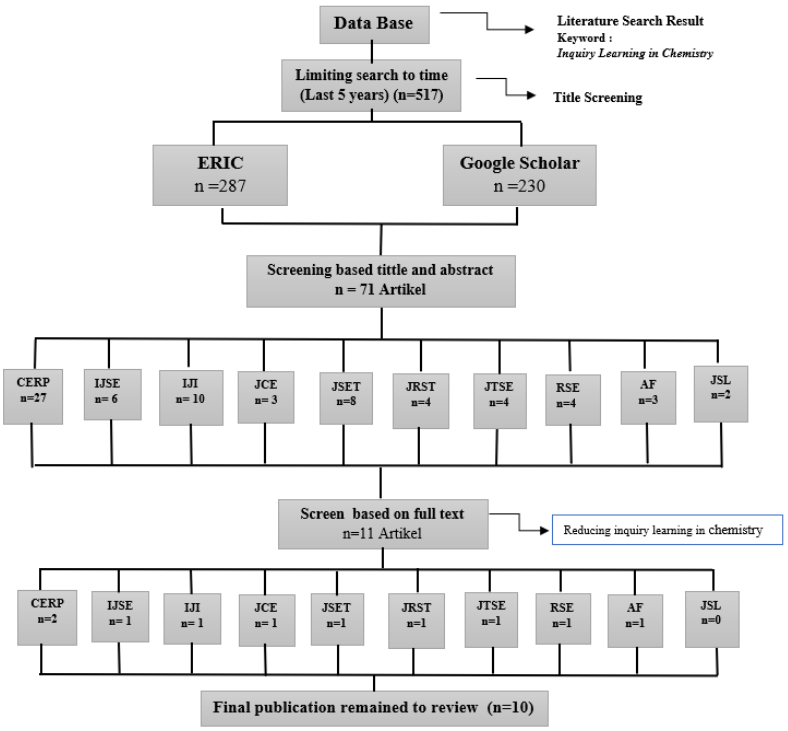

Figure 1. The Diagram of Article Screening Plot

Note:
CERP : Chemistry Education Research and Practice
IJSE : International Journal of Science Education
IJI : International Journal of Intruction
JCE : Journal of Chemical Education
JSET : Journal of Science Education and Technology
JRST : Journal of Research in Science Teaching
JTSE : Journal of Turkish Science Education
RSE : Research in Science Education
AF : African Journal of Research in Mathematics, Science and Technology Education
JSL : Journal of Science Learning

Table 1. The results of the screening of articles that will be reviewed

No.	Judul Artikel	Terindeks	Jenis Jurnal
1.	*Students' Attitudes, Self-Efficacy and Experiences in a Modified Process-Oriented Guided Inquiry Learning Undergraduate Chemistry Classroom*	*Q2*	*CERP*
2.	*Step by Step Learning Using the I Diagram in the Systematic Qualitative Analyses of Cations within a Guided Inquiry Learning Approach*	*Q2*	*CERP*
3.	*Comparing the Effectiveness of Verification and Inquiry Laboratories in Supporting Undergraduate Science Students in Constructing Arguments around Socioscientific Issues.*	*Q1*	*IJSE*
4.	*The Effectiveness of Inquiry Social Complexity to Improving Critical and Creative Thinking Skills of Senior High School Students*	*Q2*	*IJI*
5.	*Promoting Student Development of Models and Scientific Inquiry Skills in Acid-Base Chemistry: An Important Skill Development in Preparation for AP Chemistry*	*Q2*	*JCE*
6.	*Implementation of Game-Transformed Inquiry-Based Learning to Promote the Understanding of and Motivation to Learn Chemistry*	*Q1*	*JSET*
7.	*Analysis of Inquiry Materials to Explain Complexity of Chemical Reasoning in Physical Chemistry Students' Argumentation.*	*Q1*	*JRST*
8.	*The Effect of Chemo-Entrepreneurship Oriented Inquiry Module on Improving Students' Creative Thinking Ability*	*Q2*	*JTSE*
9.	*Process-Oriented Guided Inquiry Learning (POGIL) as a Culturally Relevant Pedagogy (CRP) in Qatar: A Perspective from Grade 10 Chemistry Classes*	*Q1*	*RSE*
10.	*Views on Inquiry-Based Chemistry Teaching Practice: Linking Contextual Challenges and Specific Professional Development Needs in Some Tanzanian Schools.*	*Q3*	*AF*

▪ RESULT AND DISSCUSSION

The Influence of Inquiry Learning Model on Chemistry Learning Goal's Achievement.

The learning model is one of essential components in learning that determines students' success in studying (Slameto, 2010). In the learning process, the teacher has to get a strategy so that the student can study effectively and efficiently; thus, the determined learning goal will be achieved (Sudjana, 2005). According to Arends (1997), there is no the best learning model among the others because each learning model feels good if it is already tested to teach a particular subject material (Arends, 1997). Therefore, in choosing the existing learning model, the teacher needs to select the best one to teach a particular material to the students.

The review result from some journals shows that the student's ability can be improved through the inquiry learning model. Ten review articles were screened by conducting early step analysis in the introduction to know the literature study and the plan used in the journal article. Furthermore, study the effectiveness in the inquiry learning model in each article that was proven by the effectiveness result of the achieved strategy. Below is the review result from some articles about inquiry learning that positively influence the chemistry learning goal's achievement.

Table 2. The influence of inquiry-based learning on the chemistry learning goal's achievement

No.	**The Researcher's**	**Learning Score**

1	Perdana et al., (2020)	To improve the student's ability to think critically and creatively
2	Adnan et al, (2021)	To improve the student's a
3	Pitukpong et al, (2018)	bility to think creatively
4	Rahmat (2020)	To improve the student's ability to think critically
5	Dewi et al, (2019)	To improve the student's ability to think critically
6	Nalan et al, (2017)	To improve the student's ability to think creatively
7	Aisyah (2016)	To improve the student's performance and achievement
8	Jonathon et al, (2017)	To improve the student's study result
9	Treagust et al, (2018)	To improve the ability of transferring scientific concept
10	Vishnumolakala, (2017)	To improve the student's concept understanding
		To improve student's attitude, self-ability, and learning experiences on chemistry study.

The articles' analyzed results showed various inquiry learning models implemented on the chemistry learning. The influence of the inquiry learning model on the chemistry learning goals was proven can improve student's ability, such as student's critical and creative thinking ability improvement (Perdana et al., 2020; Adnan et al., 2021; Pitukpong et al., 2018; Rahmat, 2020; Dewi et al., 2019), student's performance and study result improvement (Nalan et al., 2017; Aisyah, 2016), student's cognitive improvement, student's concept understanding improvement (Jonathan et al., 2017; Treagust et al., 2018), student's perspective improvement, student's self-ability, experience, and attitude improvement. (Vishnumolakala et al., 2017).

It proved that the inquiry learning model on the chemistry learning positively influences student's ability to improve the obtained knowledge, attitude, and skill. The research results with various inquiry learning models showed that the inquiry-based learning model has an opportunity for a conducive science learning climate development. Based on these explanations, it requires further analysis of the articles that connect the student's ability with the inquiry learning model on chemistry learning.

The influence of inquiry learning on students' critical and creative thinking ability is improving significantly (Perdana et al., 2020; Adnan et al., 2021). As mentioned by Perdana et al. (2020), there is a significant improvement result reviewed from students' pretest and post-test score before and after the Inquiry Social Complexity (ISC) is implemented. The critical-creative thinking ability is related to the logical, rational, and reflective ability to systematically analyze and evaluate the information decides a correct action to be taken and ensure. The critical-creative thinking ability can be developed and implemented using Inquiry Social Complexity (ISC) learning model, where this model is a model that emphasizes on the invention, investigation, constructivism, thinking ability, and knowledge integration. A similar result was found that the inquiry learning model improves the student's critical thinking ability using the general inquiry learning model (Adnan et al., 2021). Moreover, the inquiry learning model can improve student's creative thinking ability (Pitukpong et al., 2018; Dewi et al., 2019) where the student's creative thinking ability can improve by using Argument-Driven Inquiry (ADI) model (Dewi et al., 2019; Pitukpong et al., 2018). The N-Gain average score increases by 0,63 for critical thinking ability (Adnan et al., 2021). Meanwhile, the result of (Perdana et al., 2020) N-gain score calculation showed that student's critical-creative thinking ability in the experiment class is 0,75 with a high category compared to the control class. So that the better learning model compared to

the general inquiry learning model is Inquiry Social Complexity (ISC) learning model (Perdana et al., 2020; Adnan et al., 2021). The N-Gain score on the Inquiry Social Complexity is proven to be higher than the general inquiry learning model.

The inquiry learning model not only improves the student's critical-creative thinking ability, but also improves the student's performance and study result (Nalan et al., 2017; Aisyah, 2016). Students' performance and study result improve if the students participate in the learning process actively. The active learning process can be started by the teacher providing a problem to be solved; thus, the students can solve the problem and answer the question asked by the teacher. In the Guided Inquiry Learning Approach (GILA), students are encouraged to investigate a guided activity where the student's knowledge is built up in the student's mind to be more skilled in explaining and investigating, and the students obtain more independency in learning (Nalan et al., 2017). Similar research with a different inquiry learning model shows an improvement result too, where the inquiry learning model used was Peer Instruction with Structured Inquiry (PISI) (Aisyah, 2016).

In the effectiveness comparative study and verification laboratory instruction with guided inquiry (Guided Inquiry Learning Approach), Nalan (2017) discovered that students incorporated with guided inquiry-based laboratory class show higher test score than those incorporated with verification laboratory. Likewise, Aisyah (2016) stated that Peer Instruction with Structured Inquiry (PISI) model is an inquiry learning model that requires the students to respond to the questions and methods given by the teacher through the help of other students as a peer tutor. A student can be a chosen tutor because he/she has more abilities than other students and is disposed to be trained and given an additional guiding program to be a tutor and help his/her colleagues in learning.

The student's study result is classified into three categories: psychomotor study result, effective ability study result (Treagust et al., 2018) and cognitive ability study result (Jonathan et al., 2017). The cognitive study result can improve the concept understanding, reasoning, and communication in transferring the scientific concepts (Jonathon et al., 2017; Treagust et al., 2018). The Argument-Driven Inquiry-based (ADI) laboratory learning model can improve the student's ability to transfer a concept or build an argument based on natural phenomenon facts (Jonathon et al., 2017). In the effectiveness comparison of ADI inquiry-based laboratory learning with verification model, Jonathon (2017) discovered a better significant difference in transferring scientific concepts learned in the class with ADI inquiry-based laboratory learning than in the controlled class with verification model. Likewise, the influence of the Process Oriented Guided Inquiry Learning (POGIL) model on the chemistry learning goal's achievement also improves the student's effective results. Student's effective ability results in improvement can be seen in student's achievements. A student's effective practical ability consists of constructions such as attitude, interest, motivation, self-concept, score, and moral value. These six constructions have an essential role in chemistry learning or chemistry education in general. Treagust et al., (2018) showed the influence of the POGIL learning model in improving the affective result of junior high school students in Qatar.

Process Oriented Guided Inquiry Learning (POGIL) is a student-centered learning strategy that works in small group. POGIL learning model effectively improves

student's achievement in the experiment group with an average of 8-10% compared to the comparison group. The POGIL group score achievement is higher than the non-POGIL group for all curriculum standards and statistically significant. It is proven with effect size (Cohen 1988) in the range of 0,27 to 0,31. This achievement score indicates that POGIL can help improve students' understanding of chemistry lesson (Treagust et al., 2018).

Furthermore, the analyzed literature review regarding inquiry learning showed that the groups participated in the Process Oriented Guided Inquiry Learning (POGIL) model influenced scientific attitude, self-efficacy, attitude, and learning experiences (Vishnumolakala et al, 2017). The influence of Process Oriented Guided Inquiry Learning (POGIL) was proven can improve students' attitude, self-ability, and learning experiences in chemistry study. The learning success was proven with the ASCI v2 reliability result, and CAEQ in the form of alpha cronbach score that improved significantly viewed form student's pretest and post-test results (Vishnumolakala et al., 2017).

The Syntax of Inquiry Learning Model in Improving the Observed Variables.

The inquiry learning model is a series of learning activity that emphasizes a critical and analytical thinking process to find the answer to the problems faced by students (Sanjaya, 2010). Students are expected to answer the questions and get the correct answer through an activity series of investigation, exploration, experiment, finding, searching, and researching. In general, syntax or inquiry learning model steps consists of orientation, problem formulation, hypothesis formulation, data collection, and hypothesis examination by conducting a trial and concluding (Adi, 2016).

The effective syntax of the inquiry learning model can be seen from the student's ability improvement; the improvement of observed variables. This article has observed variables: students' critical-creative thinking ability, performance and study result, cognitive ability, concept understanding, perspective, self-ability, experiences, and attitude. According to the review result, Inquiry Learning-based chemistry learning, in general, is proven to improve student's abilities effectively. Students' ability can be improved by paying attention to syntax or steps that influence the implementation of the reviewed articles. Research about learning model implementation has been conducted to improve students' abilities. In this part, the analysis result will be explained in the several research articles regarding the inquiry learning model implementation to increase the observed variables. Below are some reviewed result articles regarding the Inquiry Learning model implementation in the chemistry learning that can be seen in Table 3.

Table 3. Some learning models on inquiry learning

No.	Researcher's Name	Learning Model
1	Perdana et al, (2020)	Inquiry Social Complexity (ISC)
2	Adnan et al, (2021)	Inquiry Learning
3	Rahmat (2020)	Inquiry Learning
4	Dewi et al, (2019)	Inquiry Learning
5	Nalan et al, (2017)	Inkuiri Terbimbing Guided Inquiry Learning Approach (GILA)
6	Aisyah (2016)	Peer Instruction with Structured Inquiry (PISI)

7	Pitukpong et al, (2018)	Argumen-Driven Inquiry (ADI)
8	Jonathon et al, (2017)	Argumen-Driven Inquiry (ADI)
9	Treagust et al, (2018)	POGIL (Process Oriented Guided Inquiry Learning)
10	Vishnumolakala, (2017)	POGIL (Process Oriented Guided Inquiry Learning)

According to a review study of some research results that integrate the inquiry-based learning model is successfully implemented in the chemistry learning activity that can be seen in Table 3. An example of a research result implementing the inquiry-based approach is Perdana et al. (2020) with Inquiry Social Complexity (ISC) learning model in the chemistry learning to improve the observed variable; student's critical-creative thinking ability. The implementation of Inquiry Social Complexity (ISC) (Perdana et al., 2020) is better than the other inquiry learning models (Adnan et al., 2021; Pitukpong et al., 2018; Rahmat, 2020; Dewi et al., 2019) because several factors influence it. In the Inquiry Social Complexity (ISC) learning model, the teacher's role is as a facilitator and observes the student's activity during the learning process. The observation process in the Inquiry Social Complexity (ISC) model syntax implementation was running optimally. The ISC learning model trained the aspects of students' critical-creative thinking ability through six syntaxes consisting of problem sensitivity, analysis, inference, elaboration making, evaluation, and novelty. It showed that the Inquiry Social Complexity (ISC) model was proven more effective in improving the observed variable; student's critical-creative thinking ability. However, the empowerment of a student's higher-order thinking ability, the critical-creative thinking ability, involves many factors such as intelligence, learning environment, and psychological character. In empowering the student's skill exploration, the teacher has an essential role in developing and implementing the formal learning in the development process and taking the correct steps so that the student's thinking ability can be empowered optimally (Perdana et al., 2020). Other than that, the teacher has to have the skill to manage the class well and facilitate the students to participate in the learning process actively.

Likewise, the Guided Inquiry Learning Approach model syntax (Nalan et al., 2017) with the Peer Instruction with Structured Inquiry model (Aisyah, 2016) can improve the observed variable in the form of student's performance and study result. The implementation of Peer Instruction with Structured Inquiry model syntax was running well, where the teacher took the proper steps so that the student's performance and study result can improve. Various steps were conducted in the Peer Instruction with Structured Inquiry learning model. In the first step, the teacher arranges study groups consisting of students with various skills. Second, the teacher explains the task solving after arranging the study group with peer teaching method. Third, the teacher gives assignments to experiment with inquiry structure. Fourth, the teacher gives the competence evaluation and observes the student's learning activity. In the next step, the teacher, tutor, and students evaluate the teaching-learning process that has been conducted. Whereas the effectiveness of Guided Inquiry Learning Approach (GILA) model (Nalan et al., 2017) was improved because it was influenced by several factors, such as the achievement improvement (21%), the development analytical thinking

ability (18%), problem-solving skill (20%), and the science process skill (17%) (Aisyah, 2016).

Besides, the inquiry-based laboratory activity (Jonathon et al., 2017; Treagust et al., 2018) can also improve the student's conceptual understanding and practical ability based on the obtained effectiveness score. Regarding the researcher's class observation, the POGIL implementation (Treagust et al., 2018) showed the accordance of activity and student-centered class environment that was facilitated by the teacher. The implementation showed the relevance of POGIL activity with the curriculum standard and resources used in the class in the form of textbooks and teacher's facilitation of POGIL in the class. Meanwhile, a similar learning model with a different syntax implementation was shown by Vishnumolakala et al. (2017), where the process of POGIL model syntax implementation can be conducted well through five aspects: first, the POGIL activity must be guided by facilitator; second, students are active to discuss the content of the presented model in the POGIL worksheet; third, students can identify and understand the chemistry concept by answering some critical thinking questions; and the last, the concept that was developed and understood by students strengthened and expanded further by answering some practices presented in POGIL learning material (Vishnumolakala et al., 2017).

Meanwhile, the Argument-Driven Inquiry (ADI) model improved the observed variable because influenced by eight steps of ADI learning model (Jonathon et al., 2017). The eight steps of ADI learning model are: identifying the assignment and questions regarding the discussed scientific phenomenon; arranging the method and collecting the data; analyzing the data and developing a tentative argument; argument session; and revising and submitting the report (Jonathon et al., 2017). The investigation was following the ADI model was centered on the questions that must answer through scientific argument resulted by each student group.

The reviewed study from some articles showed that the most effective inquiry learning model implementation to improve the observed variable on the chemistry learning is Inquiry Social Complexity (ISC) learning and Argument-Driven Inquiry (ADI) models. They were influenced by the ADI (eight syntaxes) and ISC (six syntaxes) inquiry learning model steps which are more comprehensive than the other inquiry model syntaxes, according to the reviewed articles. It was proven with a higher N-Gain score in the Inquiry Social Complexity (ISC) and Argument-Driven Inquiry (ADI) than the other inquiry learning models. The average of N-Gain score improves in the number by 0,63 for the critical thinking ability (Adnan et al. 2021); meanwhile the result of (Perdana et al., 2020) N-Gain score calculation showed that the student's critical-creative thinking ability is 0,75 and categorized as high than the control class. Hence, the better learning models based on the reviewed articles are Inquiry Social Complexity (ISC) (Perdana et al., 2020; Adnan et al., 2021) and Argument-Driven Inquiry (ADI) (Dewi et al., 2019; Pitukpong et al., 2018) learning. Based on this result, the inquiry learning model can be a proper solution to improve the goal's achievement from the chemistry learning. The inquiry learning model guides the students to work independently and encourage students to find the learned concept through the presented steps. The teacher, as a facilitator, also accompanies the discussion process, resulting in the student's understanding on the learned concepts improving and developing.

▪ CONCLUSION

Based on the reviewed articles, the obtained conclusion is that the influence of inquiry learning on the improvement of chemistry learning goal's achievement has a positive effect on the student's skill improvement, such as: the improvement of student's critical-creative thinking ability, student's performance and study results, student's cognitive, concept understanding, student's perspective, self-ability, experience and attitude.

The pratical implementation of the inquiry-based learning model to improve the observed variables can be reviewed through the presented steps on the models. According to the reviewed articles, it shows that the most effective inquiry learning model syntaxes are Inquiry Social Complexity (ISC) and Argument-Driven Inquiry (ADI) learning model because it is influenced by the ADI (eight syntaxes) and ISC (six syntaxes) inquiry learning model steps which more complete and comprehensive than the other inquiry learning model syntaxes. In those syntaxes, students are encouraged to be involved actively in finding a solution to the faced problems in the class with the teacher's guidance that rolled as a facilitator in the learning process.

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