

Critical Thinking Skills Analysis of Chemistry Pre-service Teacher in Developing Chemistry-learning Tools Based on Islam-science Integration

(Study at Department of Chemistry Education,
Faculty of Science and Technology, UIN Sunan Kalijaga Yogyakarta)

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Abstract

Critical thinking is the ability to think clearly and rationally about what to do or what to believe. It includes the ability to engage in reflective and independent thinking. This study aimed to determine the critical thinking skills of pre-service teachers of chemistry education department at Faculty of Science and Technology, UIN Sunan Kalijaga; what barriers are owned by the students to develop critical thinking skills in developing learning tools; and efforts to what can be done by the department to improve those critical thinking skills. This research is a descriptive study that carried out in several stages: the development of research instruments (analysis learning tools sheet, critical thinking skills scale, interview guides, FGD questions guide); research instruments validation; data collection; data analysis; as well as inference and reporting. Analysis of the learning tools compiled by the students shows that there were weaknesses in determining student learning outcomes, which was found 60% selection of the type of assessment does not match with the learning objectives. Critical thinking skills of students are at a good level with an average ideal percentage of 72.7%. The lowest score obtained in "advanced clarification" aspect, which was also proved from the interviews, the students did not have enough knowledge to explain more detail what was said previously. FGD with professors indicated that the necessary coordination meeting between lecturer at the beginning of each semester so that the distribution of matter in all subjects do not overlap.

Keywords: Critical thinking, Pre-service teacher, Learning tools, Science-islam integration.

Introduction

Global improvement demanding adaptive education to community needs. Various studies in various fields of social sciences shows that students who graduate from the various educational institutions in different countries do not have the ability to compete on a global scale because they do not have the critical thinking skills (Frijters et al., 2008). Scientific activity, which is the main activity lecturing process, actually requires critical thinking, but it is surprising to see at least graduates (students) who can demonstrate this capability, including chemistry student teachers. Inability output of learning to think critically has become a national issue that must be addressed (Quitadamo et al., 2008).

Previous research shows that most students are not able to develop a quality argument. This study indicates that the student requires experience and

practices how to express, recognize and submit arguments and learn things that can contribute to strengthen their reasons (Chowning et al., 2012). Similarly, the results of preliminary study conducted in 3 classes at the Chemistry in High School II (*mata kuliah Kimia Sekolah II*), Elementary School Learning Science (*mata kuliah Pembelajaran IPA SD*), and Popular Scientific Writing (*mata kuliah Penulisan Karya Ilmiah Populer*) show the students were still not able to show the expected performance, especially in developing Lesson Plan (RPP) and practicing in writing lesson plans. The lesson plan they produced was not ideal as the requirement. Furthermore, students still have difficulties in translating core competencies (KI) and the Basic Competency (KD) and to formulate indicators of learning based on the KI and KD. Some indicators of "learning outcomes" made, does not match with the learning strategies and assessment instruments used. On the other hand, students also

have difficulty in how to construct and develop ideas, preparing arguments in essay writing, including addressing knowledge that has been held into a writing (both scientific and popular). This indicates that students do not yet have the critical thinking skills demonstrated in the daily academic performances. Therefore, it can be assumed the lecture for chemistry teacher candidates considered have not been able to equip student with sufficient critical thinking skills as the provision of professional teacher candidates.

Furthermore, the result of preliminary study shows the lack of connection between mastery of the facts of chemistry and how chemistry is used, and to find the relationship between chemistry/science and Islamic values. In line with that, the White et al., (2009) argued most students cannot unite them and looked at the facts and theories as separate concepts. Lectures that had occurred were not effective to trigger deep thoughts and retention of long-term concept. This is evident from the results of a comprehensive examination (students who have taken the exam before taking final exam/*munaqosyah* covering all chemicals and educational materials that have been studied), where only 2 of the 65 students who passed the first stage of the test. These results suggest there are still many students who have the misconception that the most appropriate chemistry is taught through recall facts and forget collaboration and troubleshooting of chemical investigation/science. Although some countries have integrated the critical thinking skills in the curriculum, in fact the students have not really able to demonstrate such skills as learning science conducted no systematic and organized as well as the lack of emphasis on critical thinking skills explicitly (Quitadamo et al., 2008; Darland & Jeffrey, 2012).

Global challenges require education to prepare adaptive chemistry teacher candidates to the times and needs of the community. Teachers in Indonesia are required to have four core competencies (professional, pedagogical, personal, and social). Therefore, the curriculum of the Teacher Institutions (LPTK), including the Department of Chemistry Education, Faculty of Science and Technology, UIN Sunan Kalijaga directed at developing this competence. Accordingly including Islamic Universities (PTKI), the curriculum should not only be compiled based on high education standards that exist, but need a special concern which shows a higher institution of Islam. In other words, chemistry teacher candidates from UIN should have specific characteristics compared to the chemistry teacher candidates from other universities.

Department of Chemistry Education has made various efforts to develop a distinctive curriculum, evidenced by the design of several courses which require professors to incorporate the content of Islam as one field of study (eg integration courses Islamic

Science, chemistry courses and educational courses). In addition, educational courses are also directed to prepare and equip prospective chemistry teacher with four-novice teacher competence (professional, pedagogical, personal, and social). One of the core competencies of teachers is pedagogic competence, where competence requires teacher candidates to proficiently manage learning chemistry, ranging from planning and assessment activities. One of the activities is to develop a learning plan tools. Chemistry teacher candidate in this department is equipped with some basic teaching skills, including how to manage classroom. These skills not only in one course, but embedded in some courses. As known, the preparation of the learning tools that consists of a syllabus, lesson plans, teaching materials, and assessment instruments are activities that should be done before teacher perform in the class.

In order to implement the learning process well, teachers need to make careful planning, including one to develop a learning tool. Learning tools are developed should be based on the integration of Islam and science where students with creative able to relate what they have learned through several courses and poured it into a learning device used for the training of teaching, through the course of Chemistry Schools I and II, Microteaching (PPM), and Program Exercise Professions (PLP). Thus, it is important to analyze critical thinking skills possessed by students so that teachers can prepare lectures strategy that can improve these skills.

To develop the teaching of Islam-based integration of science, critical thinking skills are needed. Students must be able to process both content knowledge of chemistry, education, as well as Islamic values into a single device that is intact and integrated learning. Governments in some countries propose one way to prepare students who are ready to compete with the real problem-based learning environment and apply knowledge in a way that is creative and innovative. In addition, students should also be aware of how they think, not just to know what they are thinking (Bransford & Donovan in Quitadamo et. Al. 2008). How big is the benefit of a person, how he positioned himself and realize how to think about problems in a creative way requires critical thinking skills. These skills are also considered as one of the essential skills that directly influence the professional and academic success (Quitadamo et al., 2008). Given the importance of critical thinking skills, some countries have attempted to integrate the learning of critical thinking to prepare its graduates. With high critical thinking skills expected student teachers ready to become professional teachers.

Thus, this research aims to:

- a. analyze level thinking skills critical of students in the Department of Chemistry Education, Faculty of

Science and Technology, UIN Sunan Kalijaga Yogyakarta in academic year 2015/2016;

- b. identify any obstacles that are faced by students in developing critical thinking skills, especially in developing learning tools;
- c. Seek alternative efforts to improve students' critical thinking skills of those students.

Literature Review

Learning Tools

One of the competencies possessed by the teacher is obliged pedagogic competence, that has:

1. insight or educational foundation;
2. understanding of the learners;
3. ability to develop curriculum or syllabus;
4. ability to design learning;
5. the ability to implement an educational learning and dialogue;
6. ability to use learning technologies;
7. capability to evaluate students' learning outcomes; and
8. develop the ability of learners to actualize various potentials (Suprihatiningrum, 2014: 121).

One of these competencies is the ability to design learning. Lesson plan drawn up in the form of learning tools such as: syllabus, lesson plans, teaching materials, instructional media, and assessment instruments. Good planning and quality of learning will create a good learning process so that the achievement of learners is also the maximum. Competence in terms of making learning device an absolute thing that must be mastered by prospective teachers. This capability would not be able to appear instantly, but requires a structured exercise.

Especially for prospective chemistry teachers in PTAI, the skills in integrating Islamic values in the preparation of learning tools should also be trained. That is, students are also required to observe and then integrate Islamic values related to chemical content and then combined into a single study material intact. This skill is not easy because it requires higher-order thinking skills, one of which is the ability to think critically.

Critical Thinking Skills

Critical thinking is defined as the activity of mental discipline to think reflectively and sensible for evaluating arguments or propositions to make a decision what to believe or do (Huitt, Ennis in Çimer, 2013). Unlike other intelligence, critical thinking can be improved and developed, and does not depend on age (Walsh & Paul, Lipman et al. In Çimer et al., 2013). Critical thinking is also a cognitive skills and strategies

that increase the likelihood of the expected results, thinking that aim, reasoned, and goal-oriented. This thinking includes solving the problem, formulate a conclusion, the possible, and make a decision (Halpern in Frijters at.al, 2008). Psychologists conceptualize critical thinking as higher-level thinking skills and focus on the learning process and the corresponding instructions. Critical pedagogy emphasizes the critical and democratic citizenship as well as the importance of the development of value.

Critical thinking is composed of behavioral tendencies (such as curiosity and open mind) and cognitive skills (such as analysis, inference, and evaluation) (Ennis in Quitadamo et. Al., 2008). Behavioral tendency for critical thinking appears to be changing, at least for the short-term (Giancarlo & Facione, Ernst & Monroe in Qutadamo et.al., 2008). But the increase in critical thinking skills can significantly occur for at least nine weeks (Quitadamo & Kurt in Quitadamo et al, 2008). Benefits academic and personal activities of critical thinking is very clear, students tend to get better results, have a better personal reasoning, and hired well (Quitadamo et al., 2008)

Critical thinking is not the same as the accumulated information. One with a good memory and has a lot of facts do not mean a critical thinker. A critical thinker is able to conclude from what he knows, and knows how to use information to solve problems, and seek sources of information relevant to him.

Critical thinking is not the same as argumentative attitude or denounces others. Critical thinking is neutral, objective, unbiased. Although critical thinking can be used to indicate errors or bad reasons, critical thinking can play an important role in working together to find the right reasons and doing constructive tasks. Critical thinkers capable of introspection about the possibility of bias in the reasons put forward. Someone who has the critical thinking skills have characteristics:

- a. Able to make inferences and solutions that are accurate, clear, and relevant to the existing conditions.
- b. Open thinking systematically and have the assumptions, implications, and consequences are logical.
- c. Communicate effectively in solving complex problems. Critical thinking is a way to create personalized targeted, disciplined, controlled, and corrective against yourself. This of course requires effective communication skills and problem-solving methods and a commitment to change the paradigm egocentric and sosiosentris us.

Some of the criteria that can be used as a standard in the process of critical thinking is clarity, accuracy, precision, relevance, logical thinking is used, the breadth of viewpoints, depth think, honesty, the

completeness of the information and what are the implications of the solutions that we put forward.

Basically critical thinking skills developed as indicators of critical thinking skills that consists of five major groups, namely (Costa, 1985: 54):

1. give a simple explanation (elementary clarification);
2. build basic skills (basic support);
3. concluded (interference);
4. provide further explanation (advanced clarification);
5. set the strategy and tactics (strategy and tactics).

Broadly speaking, critical thinking skills include the ability of the core as shown in Figure 1.



Figure 1. Core critical thinking skills (Source: Landis, 2015)

- a. Interpretation - categorization, decoding, to clarify the meaning
- b. Analysis - examine the idea, identify arguments, analyze arguments
- c. Evaluation - assessing the claim (statement), assess arguments
- d. Inference - a claim questioned, think of alternatives (eg, differential diagnosis), draw conclusions, solve problems, make decisions
- e. Explanation - stated the problem, declare the result, reveal the truth procedure, argued
- f. Self-regulation - examine yourself, self-correcting

Critical thinking is one of the higher-level thinking skills (Higher Order Thinking Skills/HOTS) in addition to creative thinking, problem solving, and reflective thinking. HOTS associated with the top three levels of Bloom's taxonomy. However, it should be emphasized that only the classification of Bloom's taxonomy to categorize the learning objectives, while HOTS as well as critical thinking is a larger-scale process that essentially reflect human behavior (Çimer et al., 2013).

Method

This research is a descriptive study that aims to uncover the level of thinking skills of student

(prospective chemistry teachers), especially in preparing the integration of Islamic values and chemistry content. This research has been carried out through several stages:

1. The development of research instruments
This stage is the initial stage prior to data collection. Instruments developed include:
 - a. Sheet of learning tools analysis (lesson plans, teaching materials, assessment instruments) produced students in several courses: Teaching and Learning (*mata kuliah Belajar dan Pembelajaran*), Chemistry in High School I and II (*mata kuliah Kimia Sekolah I dan II*), Microteaching (PPM), and PLP. The lesson plan will be analyzed from the aspects in Table 1.
 - b. Scale of critical thinking skills
Scale of critical thinking skills have been prepared on the following aspects:
 - 1) Gives a simple explanation (elementary clarification);
 - 2) Build the basic skills (basic support);
 - 3) Concludes (interference);
 - 4) Provide further explanation (advanced clarification);
 - 5) Set the strategy and tactics (strategy and tactics).
 - c. Guidelines interviews to uncover the barriers experienced by students in enhancing critical thinking skills
 - d. Focus Group Discussion (FGD) question guides to find solutions to improve critical thinking skills
2. Validation of research instruments
All instruments that have been developed were validated both logical and empirical.
3. Collecting data using valid instrument
4. Analysis of the data, which includes data on:
 - a. compile skills learning device that results from some subjects;
 - b. critical thinking skills through the charging sheet scale;
 - c. interviews with students about obstacles in developing the critical thinking skills;
 - d. alternative ways to improve critical thinking skills based on the results of focus group discussions with lecturers from the Department of Chemistry Education.
5. Inference and reporting
The research report will be given to the Education Department of Chemistry as a recommendation to improve the quality of lectures and the quality of graduates (chemistry teacher candidates).

Tabel 1. Analysis aspects of lesson plan.

No.	Analysis Aspects	Indicators
A	Formulation of learning goals	<ol style="list-style-type: none"> 1. Accuracy of formula 2. Compliance with KI and KD 3. The use of the operational verb
B	The selection and organization of learning materials	The suitability of the material to: <ol style="list-style-type: none"> 1. learning learning 2. learners' characteristics 3. time allocation
C	Selection of instructional media	Conformity with the media: <ol style="list-style-type: none"> 1. learning learning 2. learning materials 3. learners' characteristics
D	Scenario/learning activities	<ol style="list-style-type: none"> 1. Compliance with the models and learning methods: <ol style="list-style-type: none"> a. learning learning b. learning materials c. learners' characteristics d. scientific approach 2. Compliance measures during each stage of learning and the time allocation
E	Selection of learning resources	The suitability of learning resources by: <ol style="list-style-type: none"> 1. learning learning 2. learning materials 3. learner's characteristics
F	Assessment of learning outcomes	<ol style="list-style-type: none"> 1. Conformity assessment techniques with learning outcomes and indicators of achievement of learning outcomes 2. Completeness of assessment instruments (learning process and results) 3. Clarity assessment procedures 4. Clarity scoring guidelines

Result and Discussions

Skills in developing learning tools

Analysis of the learning device in the form of 20 learning tools compiled by students are taken out of the course Teaching and Learning, Chemistry in High School I and II, Microteaching, PLP randomly. The results are shown in Table 2.

Critical Thinking Skills

The critical thinking skills scale filled out by 51 respondents obtained the results as presented in Table 3.

Table 3 shows that the critical thinking skills of students represented by 51 respondents are in a "good" category, but if observed from ideal percentage is still below 80%, except in the aspect of "set the strategy and tactics". This fact shows that the critical thinking skills needed to be improved. This skill is not only necessary when preparing students learning tools, but more broadly these skills should be applied under any circumstances.

Interviews with students about obstacles in developing the critical thinking skills

Interviews have been conducted to some respondents about obstacles in developing the critical thinking skills of aspects give a basic explanation, determine the basis for a decision, draw conclusions, provide further explanation, as well as organizing strategies and tactics. Interviews conducted to students shows that the "skills give further details" still difficult to master. Often students can not elaborate on something that has been described previously, because of the limited knowledge. For example, when students choose a Problem Based Learning (PBL) approach in preparing lesson plans, students can not explain the reasons why chose this model because they do not master the knowledge about the PBL. Likewise, when preparing learning assessment, the students said it was difficult to make synchronization types and assessment tools with the learning outcomes. Related to the preparation of learning tools that integrate Islamic values and chemistry content, students claimed having difficulty on how to integrate Islamic values into the learning scenario. Most of the Islamic material taught theoretically and stand-alone without welcoming chemical science, because most lecturers common

core courses and general institutional (Islamic courses) taught by professors outside the Faculty. Nevertheless, there is one subject that is called Islam and Science (as a compulsory faculty course) which is used as one of the subjects whose content regarding

the integration of Islam and science. Students provide advice to departments to add courses that the material contains a study of the integration of Islam and science.

Table 2. The results of the analysis of the suitability of learning tools.

No	Aspects	Conformity	Results
A.	Formulation of learning goals	70% (6/20 not suitable)	<ul style="list-style-type: none"> ▪ No one using the formulation of learning objectives using the formula ABCD (Audience, Behaviour, Conditions, and Degree) completely, especially on Behaviour and Degree. ▪ All formulas written learning objectives that are in accordance with SK/KI and KD. ▪ Still found the formulation of learning objectives and indicators do not use the word operational work.
B.	The selection and organization of learning materials	100%	Learning tools material written in accordance with the purpose of learning, characteristics of learners, and time allocation. The material formatted in some form of teaching materials, namely handouts, modules, and student's worksheet.
C.	Selection of instructional media	100%	The media used are in accordance with the purpose of learning, material characteristics, and characteristics of learners.
D.	Scenario/ learning activities	80% (4/20 tidak sesuai)	Found 4 out of 20 learning scenarios have learning steps mismatch with the chosen model. For example, they used Problem Based Learning (PBL) approach, but in the scenario, does not appear the characteristics of the model. The initial activity is not preceded by brainstorming and giving it a real problem. Problems are given only for solving the stoichiometric material. Moreover, it is not excluded to comprehensively search problems using a variety of sources, using only one source, namely books.
E.	Selection of learning resources	100%	Learning resources which have been in accordance with the purpose of learning, the material characteristics and learners. However, the sources listed less wealthy and less varied.
F.	Assessment of learning outcomes	60% (8/20 tidak sesuai)	<ul style="list-style-type: none"> ▪ Found 8 of 20 learning tools that do not fit with the purpose of learning to assessment techniques, e.g. the learning outcomes is psychomotor aspects, but the instrument assessment is the written test. ▪ Assessment instruments are also incomplete because it focuses on cognitive learning outcomes only. Eight out of 20 do not provide rubric or marking scheme.

Alternative ways to improve critical thinking skills

According to FGD with lecturers of Department of Chemistry Education, revealed that knowledge of educational theories should need to be improved through the supplementary courses. Lecturers should coordinate in advance about the content/materials that will be presented in the classroom, so that it can be analysed what course that should be deepened by students. Deep knowledge will increase "give further explanation skills" as one aspect of critical thinking

skills. Associated with the concept of integration of Islamic values and science, lecturers also need to give an example when they are teaching, so that student have an idea how to practicing the concept of integration of Islamic values and chemistry content. Furthermore, lecturers also need to create alternative models that are used in the classroom lectures, is not limited to lectures, but also with the task of project and portfolio to foster independence in learning, so that critical thinking skills can be improved.

Table 3. The result of the critical thinking skills scale by respondents.

Aspects	Total Score	Ideal Total Score	Ideal Percentage	Category
<i>Elementary clarification</i>	1330	1836	72,44	good
<i>The basis for the decision</i>	1004	1428	70,31	good
<i>Inference</i>	571	816	69,98	good
<i>Advanced clarification</i>	551	816	67,52	good
<i>Strategy and tactics</i>	1019	1224	83,25	good
Ideal percentage average			72,70	good

Conclusion

The analysis of the learning tools compiled by the students shows that there are weaknesses in determining student learning outcomes assessment, which found 60% assessment prepared does not match with the learning outcomes. Critical thinking skills of students are at a good level with an average percentage of 72.7%. The lowest score obtained on the aspect of "advanced clarification" (give further details), which is also evident from the interviews, the students did not have enough knowledge to explain in more detail what was said previously. FGD with the lecturers show they need to organize between the courses to minimalized the overlapping of materials.

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