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Analytical thinking skill profile and perception of pre service chemistry teachers in analytical chemistry learning

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Abstract. Analytical Thinking is one of the Higher Order Thinking skills that is required in Analytical Chemistry learning. The purpose of this research is to portrait the profile of Analytical Thinking skills and perception of pre-service chemistry teachers towards learning. In this study, the aspects of analytical thinking skills are measured on using indicators developed by Marzano. The subjects in this study were 15 pre-service chemistry teachers, while the research data were collected through analytical thinking test instrument and questionnaire form. Further, the data obtained are were use as a basis for the development of analytical chemistry materials. The results showed that generally the analytical thinking skill of pre-service chemistry teacher is in the low category, with the average value of 63 (on 100 scale). Specifically, the tough stage from the highest are specifying, generalizing, analyzing errors, matching, and classifying. While the questionnaire results of pre service chemistry teacher toward Analytical Chemistry learning which got high, sufficient and low marks were the aspect of teaching materials; learning strategies, affective strategies, and cognitive strategies; the role of lecturers and material significance. Thus the role of lecturers and material significance is an aspect that must be developed to improve analytical thinking skills in the learning process.

1. Introduction

Analytical chemistry is one of the section of chemistry that studies the process of separation, identification, and quantification of chemical components in natural and artificial materials [1]. Qualitative analysis gives an indication of what kind of components are present in the sample. While the quantitative analysis determines the number of certain components in a substance. Separation of components is often done before conducting an analysis. Separation ways or procedures are important to be learned in this area. Thus, analytical chemistry also focuses on improving experimental design, chemometrics, and the manufacture of new measuring instruments in order to provide the better chemical information [1]. The benefits of analytical chemistry have been applied in various fields, such as forensics, bioanalysis, clinical analysis, environmental analysis, and material analysis so that the curriculum of Higher Education of Analytical Chemistry is one of compulsory subjects for Chemistry, Chemistry, or Chemical Engineering courses.

Explanation of the concept of Analytical Chemistry can be done using various relevant methods and strategies to make it easier for students to understand, for example through laboratory or practicum activities [2-5], using problem-based learning [4,6,7], problems solving [8], STEM [9], or simulation [10,11]. In this case, the learning can be a combination of conceptual understanding,



exercises, and problem teaching [6]. Problems are an important feature of analytical chemistry as it helps in developing analytical thinking and serves to expand the field of interest, so the selection of problem sequences is an important aspect of increasing deductive and inductive reasoning [6].

Analytical thinking is one of the most basic high-level thinking skills to hone 21st century skills such as critical thinking, problem solving, creative, and decision-making so that analytical thinking skills are essential for prospective teachers as basic skills. Marzano put forward an operational definition of low-level thinking skills that involves access and understanding of existing knowledge, while the ability to think at the high level of the creation of new knowledge [12]. In this regard, Marzano presents a framework that not only distinguishes between the two, but also builds knowledge as a series of hierarchically structured cognitive processes, such as scaffolding, is an inherent feature of taxonomy. With scaffolding structures, it is easier to design assessments, plan instructional activities, and generate accurate and precise feedback toward higher-order thinking [12].

Analytical thinking allows students to think logically, about the relationship between concepts and situations they face, because by analytical thinking involves the ability to (1) categorize the problem into its parts and understand the passage, (2) explain the function of a system, the reason something to happen, or how to solve a problem, (3) compare and differentiate two or more phenomena, or (4) evaluate and examine the characteristics of phenomena [13]. Analytical thinking is a powerful tool of thought for understanding the parts of the situation defined as: (1) the ability to examine and disentangle facts and thoughts through strengths and weaknesses; (2) develop the capacity to think wisely, intelligently, solve problems, analyze data, remember, and use information [9]. Thus, in the study of analytical chemistry, analytical thinking skills are needed by chemistry teacher candidates because in problem solving is closely related to the analytical process. This study aims to determine the profile of analytical thinking skills and perceptions of prospective chemistry teachers in Chemistry in Analytical Chemistry.

2. Research method

This research uses descriptive method with research subjects of 4th semester pre service chemistry teacher at university in Cirebon. The instruments used are: (1) test of analytical thinking skill to measure analytical thinking skill, (2) questionnaire of attitude scale to know perception of pre service chemistry teacher toward Analytical Chemistry learning process which cover 6 aspects, cognitive strategy, affective strategy, materials, learning strategies, lecturer roles, and teaching materials. All the data generated is explained through descriptive analysis.

Conversion of value in percentage form using the following formula: $\text{Value} = (\text{raw score of acquisition}) / (\text{Ideal Maximum Score}) \times 100\%$, then converted to qualitative form using conversion guideline The five-point benchmark assessment [PAP] [14] is as follows:

Table 1. PAP qualification.

| Value Range (%) | Qualification |
|-----------------|---------------|
| 90-100 | Excellent |
| 80-89 | Good |
| 65-79 | Moderate |
| 55-64 | Poor |
| 0-54 | Very Poor |

3. Result and discussion

3.1. Analytical thinking skills

The result of the analytical thinking skill of the pre-service chemistry teacher is shown in figure 1.

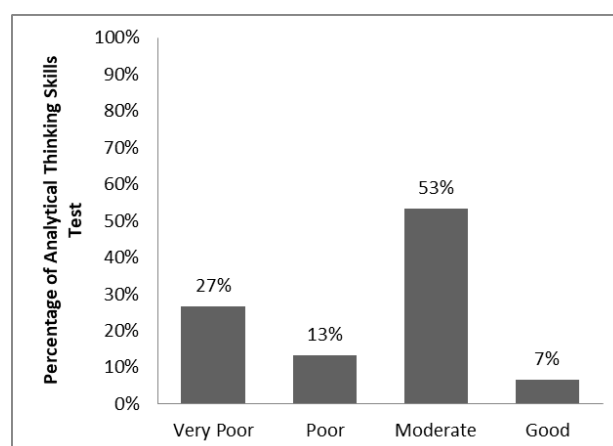


Figure 1. Analytical thinking skills test results.

The results of an analytical thinking skill test of 15 prospective chemistry teachers were 27% very poor, 13% poor, 53% moderate, and 7% good. While the average test result of analytical thinking skills is 63, are in the low category. This can mean that students have not been able to decipher or separate a thing into its parts and look for links between the parts. The lecturers must play an active role in asking questions or problems through simple analogy [13] to students to analyze accurately, but the observations show that students still tend to be trained to answer questions by memorization, so that students' analytical thinking skills are still not visible. Similar results were found in a study conducted by Irwanto et al and Winarti [2, 15], measurement of all aspects of analytical thinking ability acquired low categories because teachers have not fully optimized students' analytical thinking skills in the learning process.

The indicator of the analytical thinking skills of the pre service chemistry teacher presented in figure 2 is an indicator of analytical thinking skill developed by Robert Marzano, consisting of matching, classifying, analysis error, generalizing, and specifying [12, 16, 17]. The 20 questions were given, 15 of them had a low average (the number of students who can answer correctly is less than a score of 60), so based on these analytical indicators, the aspects of low analytical skills (consecutive) are specifying, generalizing, analyzing error, matching, and classifying.

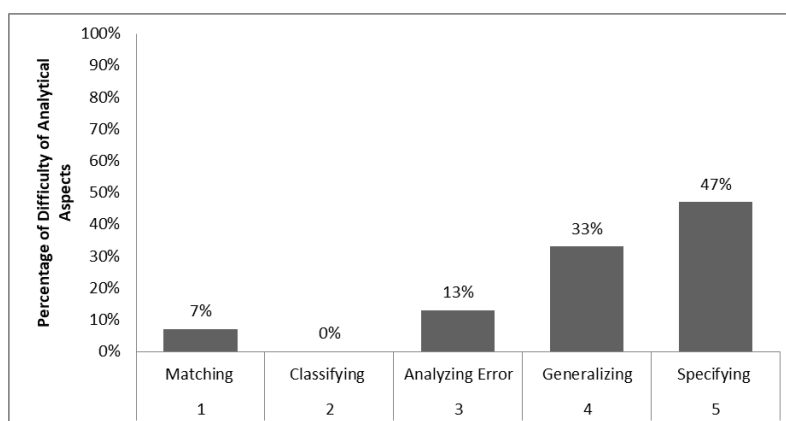


Figure 2. Difficulty of analytical aspects based on Marzano taxonomy.

Activities detailing and concluding are the most difficult for students due to lack of error analysis skills. In the aspect of error analysis is the key to determining the process of generalization and specification. This is in line with research conducted by Irwanto et al [2], the low value of analytical thinking can be seen from the inability of students to describe data in the form of tables and graphs, unable to present data in interrelated graphs, unable to identify variables experiments, and can not

formulate problem formulas and experimental hypotheses. In accordance with the theory found through Taxonomy Marzano, so far students have only worked on cognitive systems [12, 17]. Whereas to lead to high-level thinking skills, there are three interrelated mental systems, namely information, mental procedures, and psychomotor procedures. The analysis phase involves expanding students' knowledge as they discover new relationships and applications [8]. Obviously, this process can be achieved after the student has successfully passed the retrieval task (asking students to access the exact same information when it was first presented) and the comprehension (when students can articulate and/or present the most important characteristics of non-linguistic representation of information, concepts, or ideas).

Based on the results obtained in figure 2, the matching aspect is more difficult to understand than the classifying aspect. This may be due to several factors such as lack of exercise in the analytical chemistry learning process. Lecturers have not fully optimized the student to the analytical thinking process e.g. through problems associated with daily life [9], or interpreting information in a new context so that the ability to match / distinguish more difficult than grouping. Through matching aspects, students will be able to identify similarities and differences in information, mental procedures, or psychomotor procedures. While classifying aspects of the student will be able to identify the superordinate and subordinate categories associated with information, mental procedures, or psychomotor procedures [17]. Research of analytical ability using Bloom's taxonomy performed by Winarti [15] also shows differentiating indicators lower than organizing. The findings of the research are new, that there is a significant relationship between the location of the school (rural or urban) to students' thinking ability analysis.

3.2. Student perceptions of analytical chemistry lectures

Students' perceptions are revealed to know how far the learning of Analytical Chemistry is done through a closed questionnaire with assessment indicators always, occasionally, and never. The summary of the results of data analysis on student perceptions is presented in Figure 3, which is the students' perception on each aspect in the lecture. Several aspects of student perception in this research are: (1) cognitive strategy, (2) affective strategy, (3) material meaning, (4) learning strategies, (5) lecturer's role, and (6) teaching materials.

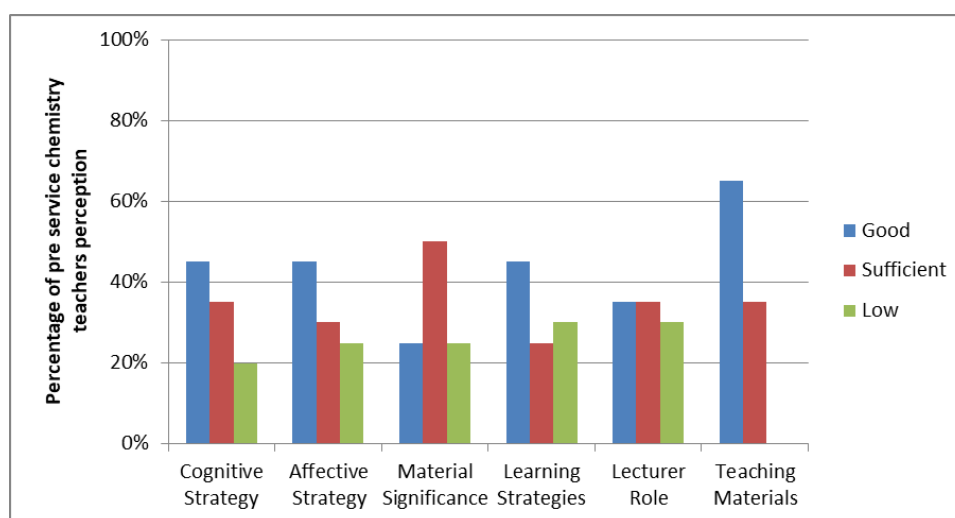


Figure 3. Perception of pre service chemistry teachers for each learning aspect.

The result of the perception from 15 students who fill the questionnaire with good category for each aspect is (1) teaching materials, 65%; (2) cognitive, affective, and learning strategies, 45%; (3) lecturer's role, 35%; and (4) material significance of 25%. The results of sufficient perception include (1) 50% material significance; (2) cognitive strategies, lecturer roles, and 35% teaching materials; (3)

affective strategies 30%, and 25% learning strategy. While the result of low perception consist of (1) learning strategy and lecturer role 30%, (2) material significance and affective strategy 25%; and (3) a cognitive strategy of 20%.

Based on the results of student perceptions, the aspect of teaching materials included in the category of good, meaning that students are satisfied with the teaching materials used by lecturers, the textbooks related subject material available, supported by media used is based on technology (use of power point presentation), so students are easy to understand the content. This is consistent with the research by Fakayode [18], Students who have read the primary literature change the way they write and spend more time checking the numbers as well as comprehending the next article more fully so that it can be used in teaching methods to achieve various goals.

Cognitive, affective, and learning strategies are considered sufficient, meaning that the learning strategies that have impact on students' cognitive and affective strategies. In Analytical Chemistry lectures, teaching strategies by lecturers provide good effects on students to manage cognitive strategies in understanding the materials and affective strategies as student motivation, for example realized in their willingness to always come on time and follow the lecture well. Learning strategy conducted by the lecturer is considered good by the students because the lecturers in the lecture process in addition to using the lecture method, also often conduct discussions. Student affective strategies are also sufficient, most students are not yet accustomed to creating concept maps. If not given the task by lecturers, only a few students who read the material both before and after the lecture, so that self-motivation is still not formed. While in the aspect of material significance, most students consider Analytical Chemistry easy to understand because it can be observed directly and easily also to be practiced. However, the limited facilities and creativity of lecturers in the packaging of materials caused Analytical Chemistry to be difficult.

While the aspects of material significance and the role of lecturers gain less perception than students. This is seen from the statement regarding the material presented is still considered too difficult because most of the material delivered is not supported by the process of practicum or demonstration that can be experienced directly by the students so that this impact on the significance of materials and cognitive strategies in some students. Practicum is very important to be taught in Analytical Chemistry because the competence in analytical chemistry is a vehicle for developing thinking and creativity [19]. In addition, in practicum activities can be performed a maximum performance assessment, namely through exercises that will lead students to know what should be done and prepared by students, in accordance with the criteria that exist in the performance assessment. Furthermore, concepts acquired through practical activities will provide long-term memory effects [2], one of which is Kovarik [20], the use of laboratory experiments based on inquiry / Guided-Inquiry Laboratory Experiments (Giles) gives students the freedom to design and implement experiments that can stimulate student achievement and interest in learning science, technology, engineering, and mathematics.

Thus, the results of analytical tests and student perception questionnaires, students' analytical thinking skills are still poor can be caused by several factors, such as in delivering the material, lecturers still dominate and have not invited students to think high level, although in the presentation lecturers have been using multi representations, i.e. images, graphics, mathematical, and verbal. But the process of learning and practice questions given are still memorized. The implication is that lectures lack students in developing pedagogical competence, especially in choosing effective learning method, so that material meaningfulness is decreasing and students assess Analytical Chemistry as difficult.

4. Conclusion

Analytical thinking skills of pre-service chemistry teacher are in the poor category, especially the students' ability in specifying, generalizing, and analyzing errors. While the perception of pre- service chemistry teachers toward the learning process is the aspect of teaching materials get a good

perception, learning strategies, affective strategies, and cognitive strategies get sufficient perception, while the significance of the material and the role of lecturers get low perception.

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