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Potential of Reflective Thinking Skills as a Bridge for Students' Prior-Knowledge and Chemistry Experiments Skills

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Abstract: ***The research on how to the prior knowledge of those students will enter the chemistry experiment laboratory activity, mainly in the synthesis of inorganic compounds was conducted using mixed methods design. The subjects were the 4th semester of chemistry students of chemistry pre-service teachers of 2 universities in Indonesia. This study showed that 69% of students know about the concept, but only 17,5% of students who understandthe interrelation of the concept with the experiment properly, 78% of students remained at levels 1 and 2 in terms of the ability to think reflectively. This study shows that there is a considerable gap between the students prior-knowledge with in-depth understanding of experiments. Low reflective thinking skills can be one caused. Appropriate experimental design should be designed so as to be able to overcome this gap, and becoming a bridge as a reflective thinkingtool.***

Keywords: Prior-Knowledgee, Reflective Thinking, Experiment Skills

1. Introduction

Learning through the experiments in the laboratory hasmany benefits for students consciously or not that they can get whether it is general or specific. Learning through the experiments in the laboratory are not only just useful for teaching the theoretical materials that can not be taught in other places, but can also cultivate psychomotoric ability, improve their ability to follow and analyze the instructions, familiarize the students with equipment/ instruments and lab equipment, familiarize the students to designing and constructing experimental equipment, improve skills/observation skills, improve expertise/skills in gathering and interpretation of data, improve the ability to explain the experimental results, improve the ability to write coherently and good arguments and focus, improve the ability of self-learning, encourages independence of thought, thought provoking in-depth interpretation of experiments, improve student skills in solving the problems with large numbers of variables and many possible ways of solving them, encourage initiative, spirit of trying, and as a sense of empowerment, increase personal responsibility and reliability to conduct experiments, instill the ability to measure precisely and carefully, foster trust / confidence in the ability of self, foster ingenuit / expertise, strengthening confidence in the truth of the theories, instilling the ability to design experiments and interpret the datas, trained technical report writing, satisfy the curiosity of students, developing a scientific attitude and understanding of scientific methodology/ engineering through experimental investigations (Rahayuningsih & Dwiyanto, 2005). The large number of learning through experiment in the laboratory can cause designing a laboratory that can meet all of these purposes being a hard thing. But at least, the activities of experiment in laboratory can be designed to achieve some specific goals of experiment.

In recent years, new information based on scholarly research has been gathered regarding the limitations and advantages of the chemistry laboratory. In addition, the following important reasons continue to be relevant; school laboratory activities have special potential as media for learning that can promote important science learning outcomes for students; teachers need knowledge, skills, and resources that enable them to teach effectively in practical learning environments; teachers need to be able to enable students to interact intellectually as well as physically, involving hands-on investigation and minds-on reflection; students' perceptions and behaviors in the science laboratory are greatly influenced by teachers' expectations and assessment practices and by the orientation of the associated laboratory guide, worksheets, and electronic media; teachers need ways to find out what their students are thinking and learning in the science laboratory and classroom (Hofstein, 2004).

For conducting a good skills in chemistry experiment, the students should have goodprior knowledge of chemistry concepts closely related to the experiments. Lack of prior-knowledge will make the students difficult in the process of laboratory experiments (Rahayuningsih & Dwiyanto, 2005).Inadequate prior-knowledge can also dissociate the gap between theoretical understanding and the skills of experiment. Previous researchers suggested that there is gap between theory and practice (Allsopp et al, 2006) that wouldmake students difficult to integrate their previous concepts that they have understood to solve the problems in conducting the experiments.

Before studying the new science, the students has had prior knowledge obtained from the recent level of education, or previous levels, and their real-life experiences. Students' prior knowledge is not something that they had from their previous teacher but it is obtained through processed by the students themselves to become knowledge. In each students' learning stages, consciously or unconsciously, affect to the prior-knowledge of students before obtaining a new knowledge. Because they are not always in the same environment before, every students will have different prior knowledge.

Previous research showed that there is variation between students' prior knowledge and academic self-beliefs. This variation influences students' achievement and should be taken into account in instruction (Hailikari, 2009). Students' understanding of concepts in experiments is indispensable thing in achieving the objectives of experiments. In the real experimental learning and understanding the chemical concepts before, during and after the experiment have close relationship (Reid and Shah, 2006). So, it needs a bridge, which can be fill the gap between theory and practice.

Reflective thinking skills can be one of the bridges. Previous research showed that reflection helps narrow the gap between theory and practice, ultimately enhancing practice (Ruth-Sahd, 2003). Reflective thinking is an active, persistent, and careful consideration of a belief or supposed form of knowledge, of the grounds that support that knowledge, and the further conclusions to which that knowledge leads (Dewey, 1933). Reflective thinking is a part of critical thinking, but more focuses on the process of making judgments about what has happened. Reflective thinking helps students develop higher-order thinking skills by prompting students to a) relate newknowledge to prior understanding, b) think in both abstract and conceptual terms, c) apply specific strategies in novel tasks, and d) understand their own thinking and learning strategies. However, reflective thinking is the most important in prompting learning during complex problem-solving situations because it provides students with an opportunity to step back and think about how they actually solve problems and how a particular set of problem solving strategies is appropriated for achieving their goal (Koszalka, 2012).

Reflective thinking processes provide opportunities for students to develop their skills and help them solve specific problems more quickly. In addition, the preservice teachers will be able to use their knowledge in a real experiment (Gurol, 2011).

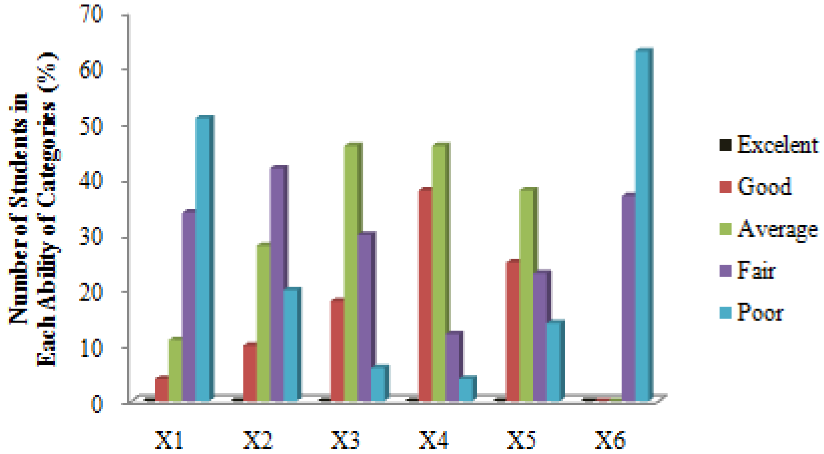
This article explained the study of the potential of the students prior-knowledge of inorganic chemistry concepts which are closely associated with experiment and its interrelation with reflective thinking skills, as a very important information to design an appropriate experiments design in the future. It is also as the initial evaluation of the real condition of students before carrying out the experimentsfor improving the quality of experiments in the future.

2. Methodology

Subjects of this study were students of 4th semester of pre-service chemistry teachers, who will conduct an experimenton synthesis of inorganic compounds. They consist of three classes with a total sample is 90 students. Their prior-knowledge was gained through tests and interviews. The test was used to measure students prior knowledge on concept related to how to conduct an experiment on synthesis of inorganic compounds that they will do, while the interview was done to determine to what extent their understanding of synthesis of inorganic compounds in general. Their reflective thinking skills were assessed by using interviews. The assessment adopts the framework of Reflective Thinking Criteria proposed by Seng (2001). This study used mixed methods triangulation design (Cresswell & Clark 2007), where the qualitative and quantitative data were taken together and support each other.

3. Findings

Initial excavation of students' prior knowledge about the basic concepts in making inorganic compounds and its benefits is shown in Figure 1.



Note:	
X1 =	Knowing the things to be considered before synthesizing inorganic compounds
X2 =	Knowing the related processes to the synthesis of inorganic compounds
X3 =	Knowing the basic equipment for manufacturing inorganic compounds
X4 =	Knowing the benefits of some important inorganic compounds
X5 =	Understanding the reactions that may occur during the synthesis process
X6 =	Know the tools which can be used to the characterization of inorganic compounds

Figure 1: The Graphics of General Priorknowledge of Students Related to The Basics Concepts of The Synthesis of Inorganic Compounds and Its Benefits

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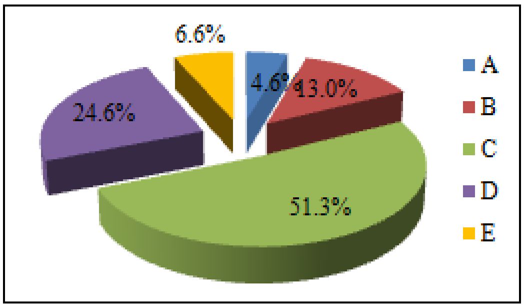
Students' interview result showed that there is no students who has experience in doing synthesis of inorganic compounds previously. There are 3.3% of students had seen the manufacture of inorganic compounds made their senior. Most of information on inorganic compounds during the synthesis process is known in terms of theory only. However, students are likely to see the manufacture of inorganic compounds as it is interesting. 88% of them have a curiosity about how making real inorganic compounds. 28% of the students see that the activities of the synthesis of inorganic compounds can help them understand a lot of things related to the problems in the laboratoryalthough most of students lacks good understanding of where and how inorganic chemical synthesis is made.

The result of students' oral test used to determine directly their prior knowledge on the concepts related to the experiment of inorganic compounds synthesis showed that some of the students are lack of ability in understanding the meaning of related concepts as shown in Figure 2.



Level Specification*)
A: The meaning of the concepts are right and well understood by students and they understand the relationships with experiments
B: The meaning of the concepts are right but not well understood by students and they know how to determine the relationship of the concept with the experiment
C: The meaning of the concept are right but not well understood by students and they has a poor ability to determine the relationship of the concept with experiment
D: The meaning of the concept is less precise and less understood and less concept with an experiment to understand the relationship
E: Lack of understanding of the meaning of the concept and do not know the relationship between the concept with the experiments

Figure 2: Total percentage of students' ability to understand the meaning of the concept of inorganic chemistry related to the experiment

The students' interview result showed that most of students admitted that they have tended to memorize the concepts given, especially if they failed to understand the meaning of the concept well. This study showed that the tendency of students to memorize concepts without understanding its meaning and implementation will greatly affect to their ability in solving problems that arise during the experiments. Their prior-knowledge are not supported by their ability to integrate their critical thinking at the real experiments. In detail, the lack of their ability in terms of related concepts can be seen in Table 2.

Table 2: Students' ability in understanding the meaning of the concept of inorganic chemistry are closely associated with the experiment

Concept	Number of Students with Level *)				
	A	B	C	D	E
Solution	13	20	65	2	0
Thermochemistry	2	9	42	39	8
Chemistry Reactions	9	17	55	18	1
Chemical Equilibrium	2	14	60	21	3
Kinetics	4	9	48	33	6
Coordination Chemistry	2	22	70	4	2
Chemical Instruments	0	0	19	55	26

The table above shows that the student ability of Chemical Instrumentation understanding is the worst. It is understandable since they are the 4th grade studentswho had not taken that course, so that their understanding is limited. However, they need to know some important instrumentation to characterize inorganic compounds, so the experimental design should be arranged for that purpose.

Reflective thinking skills was analyzed by assessing 360 journals of 90 students, where each student has 4 journal contained problem solving reportthat requires the ability to think reflectivelyas shown in Table 3.

Table 3: Percentages of Journal Entries by Level of Reflective Thinking Skills

Level	1	2	3	4	5	6
Persentage	29%	49%	19%	3%	0	0

Table 3 shows that 78% of students place at the low level of thinkingat level 1 and 2. At this level they are included in the category/criterianon-judgmental report/description/narration of events/ supervisor's comments (level 1) danjudgmental report/description of events/problems/supervisor's comments/personal suggestions for future action with no reasons or justifications/rationale given (level 2).

4. Discussion

Knowing general prior knowledge of the students (their basics knowledge) aboutthe synthesis of inorganic compounds and its benefits was used to determinethe students understanding aboutthe synthesis of inorganic compounds, before doing the experiments. It needs to be done as a basis for designing an appropriate activities of experimental design. In appropriate experimental design will lead to obstacles in practical activities. Students' weaknesses in terms of their prior knowledge about the experiment, can be focus that will be considered to be filled in experimental design, in order the experiment process can be meaningful.

Experimental design is an effective tool for maximizing the amount of information gained from a study while minimizing the amount of data to be collected. Factorial experimental designs investigate the effects of many different factors by varying them simultaneously instead of changing only one factor at a time. Factorial designs allow estimation of the sensitivity to each factor and also to the combined effect of two or more factors.Design of experiments, also called experimental design, is a structured and organized way of conducting and analyzing controlled tests to evaluate the factors that are affecting a response variable. The design of experiments specifies the particular setting levels of the combinations of factors at which the individual runs in the experiment are to be conducted. This multivariable testing method varies the factors simultaneously. Because the factors are varied independently of each other, a causal predictive model can be determined.The reason to use design of experiments is to implement valid and efficient experiments that will produce quantitative results and support sound decision making (Telford, 2007).

A review of the functions, usability, a methodof learning in laboratory is still being done by experts during late of 30 years. Their discussions showed several concerns, findings, or problems that need to be considered, including: the high cost of labor in the laboratory that makes difficult toprovide standards facilities and resources; limitated time and number of programs causing difficulty in preparing the syllabus, both in terms of quality and quantity; ineffective existing laboratories (conventional) which do not support the development of an understanding of science concepts and the use of scientific principles for solving the problems. Based on the findings in the context of a review of the learning process in a conventional laboratory, it can be concluded that we need to add a few things, such as; activities to enhance the experience and cognitive abilities, reducing the repetitionwork, and arranging an efficient activities (Rahayuningsih & Dwiyanto, 2005). Moreover, the dominant weaknesses of majority of students in the various aspects need to be a particular concern.

For example, in this study, none of the students who have good knowledge in identifying instruments for characterizing inorganic compounds. 63% of them are categorized as fair understanding. It is understandable because they do not obtain the chemical instrumentation course before. Nevertheless, the instruments are used in experiments, so they have to know how and why they used it. Therefore,it should be one of a concern in designingthe experiments.

Interviews data showed that there is no students who has experience in doing synthesis of inorganic compounds previously. There are 3.3% of students had seen the synthesis of inorganic compounds made by their seniors. Most of the synthesis of inorganic compounds process is known by the students just as a theory of synthesis. However, students are likely to see how the inorganic compounds was synthesized, they saw it as an interesting things. 88% of them have a curiosity about how to makea real inorganic compounds. 28% of the students argued that the activities of the synthesis of inorganic compounds could help them in understanding a lot of things related to the problems in the laboratory, although the students generally were categorized in poor and fair understanding of where and how the inorganic compound was made.

Research findings provided general information on related concepts of student competences to the initial content involved in the experiment that about 69% of students have a good competences of concepts of the whole concepts. However, the percentage of students who understand the conceptsand knowhow to link it to the experiment process is only 17,5% (A and B).

Difficulties of students in understanding the relationship between concepts and experiments can be caused by several things. The results of the interview indicates that the tendency of students to memorize the concept to be one cause. 57% of students have chosen to memorize the difficult concepts. In fact memorization skills tend to be forgotten, so that processing taking place in the student self-knowledge becomes meaningless.

The tendency of students to solve the problems that are more mathematics than understanding the chemical concepts on several topics such as thermokimia, equilibrium and reaction rate can beanother factor thatcauses weakness of the students' ability to integrate this concept in practice. Only 36% of students are trying to figure out the meaning behind the math in a difficult chemistry concepts that they understand.

However, their ability to think reflectively becomes the dominant factor being the main cause of the gap of understanding. The results showed that 78% of students has low level of reflective thinking skills. Therefore, it needsfurther investigation to find out causesand solution of this problem. Correlation analysis between reflective thinking skills with the ability to master concepts related to the initial experiment has a score of 0.2515, which means the value of the correlation between themwere very low.

Reflective thinking skills should be enhanced and supported by the environment and student activities. The characteristics of environments and activities that prompt and support reflective thinking are; provide enough wait-time for students to reflect when responding to inquiries,provide emotionally supportive environments in the classroom encouraging reevaluation of conclusions, prompt reviews of the learning situation, what is known, what is not yet known, and what has been learned, provide authentic tasks involving ill-structured data to encourage reflective thinking during learning activities, prompt students' reflection by asking questions that seek reasons and evidence, provide some explanations to guide students' thought processes during explorations, provide a less-structured learning environment that prompts students to explore what they think is important, provide social-learning environments such as those inherent in peer-group works and small group activities to allow students to see other points of view, provide reflective journal to write down students' positions, give reasons to support what they think, show awareness of opposing positions and the weaknesses of their own positions (Koszalka, T. 2012).

From the characteristics above can be designed an experiment that is not only able to increase the ability of students to experiment, but it can also be a tool for students to be able to increase reflective thinking skills through the process of experimentation that gives an opportunity to students to go through the process of reflective thinking.

Good laboratory activities should provide opportunities for students to not only complete the experiment, but also gives them the opportunity to experience learning schemes such as the following.

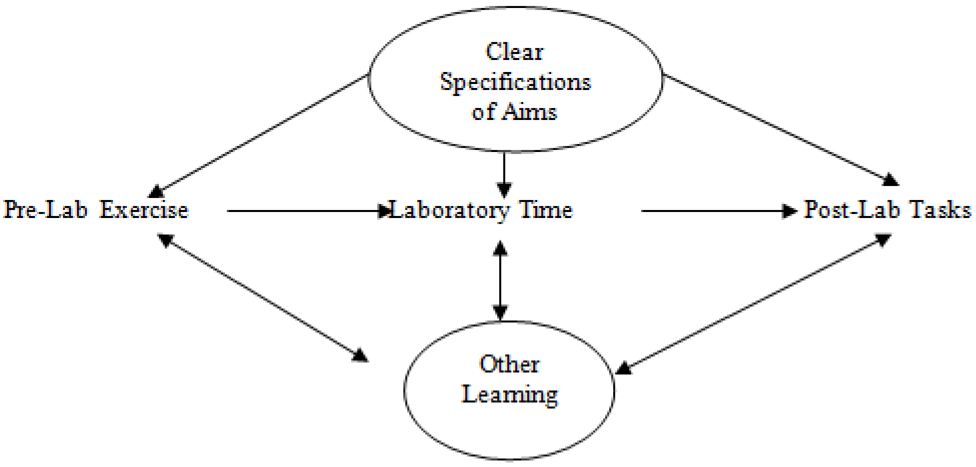


Figure 3: The Laboratory Experience (Reid and Shah, 2006)

When students are having perplexing problem, reflectivethinking helps them become more aware of their learning progress, choose appropriate strategies to explore a problem, and identify the ways to build the knowledge which they need to solve the problem. Scaffolding suggestions to promote reflective thinking can be done by;structuring lesson plans to support reflective thinking, providing lesson components that prompt inquiry and curiosity, providing resources and hand-on activities to prompt exploration, providing reflective thinking activities that prompt students to think about what they have done, what they learned and what they still need to do, providing reflection activity worksheets for each lesson plan to prompt students to think about what they know, what they learned, and what they need to know as they progress through their exploration (Koszalka, 2012).

5. Conclusion

This research found several things as reasons of of students'difficulties in understanding the relationship between concepts and experiments; such astheir tendency to memorize the concept without understanding andsolved the problems mathematically than understanding the chemical concepts on several topics. Their ability to think reflectively becomes the dominant factor being the main cause of the gap of understanding. We need a tool for students to be able to increase their reflective thinking skills through the process of experimentation that gives an opportunity to students to go through the process of reflective thinking.

6. Recommendations

The study recommends the need for further research efforts to improve the ability of students at the beginning of the experiment and to increasethe ability of the experimental synthesis of inorganic compounds, as well as efforts to improve the ability of reflective thinking, and efforts to design activities that can improve all of these abilities.

References

[1] Allsopp, D.H., DeMarie, D., McHatton, P.,& Doone, E. 2006. Bridging the Gap between Theory and Practice: Connecting Courses with Field Experiences.Teacher Education Quarterly, Vol. 33(1), pp 19-35.

[2] Creswell, J.W.& Clark, V.L. 2007. *Designing and Conducting Mixed Methods Research*. London: Sage Publications.

[3] Dewey, J.(1933). *How We Think*.Boston: DC Heath and Co.

[4] Gurol, A.2011. Determining the reflective thinkingskills of pre-service teachers in learning and teaching process *Energy Education Science and Technology Part B: Social and Educational Studies.* Volume 3(3), pp. 387-402.

[5] Hailikari, T. 2009. Assessing University Students' Prior Knowledge Implications for Theory and Practice. Dissertation, University Of Helsinki Department Of Education.

[6] Hofstein, A. 2004.The Laboratory In Chemistry Education: Thirty Years Of Experience With Developments, Implementation, And Research Chemistry Education. *Research And Practice*, Vol. 5(3), pp. 247-264.

[7] Jolly, W.L. 1970. *The Synthesis and Caracterization of Inorganic Compound.* Prentice-Hall, Canada

[8] Koszalka, T. 2012. KaAMS: A PBL Environment Facilitating Reflective Thinking. New York, Syracuse University 336 Huntington Hall Syracuse.

[9] Rahayuningsih, E. & Dwiyanto, D. 2005.Learning in the Laboratory. Yogyakarta, Education Development Center UGM.

[10] Reid, N. danShah, I. 2006. The Role of Laboratory Work in University Chemistry. *Chemistry Education Research and Practive*, Vol 8(2), pp.172-85.

[11] Ruth-Sahd, L.A. 2011. Reflective Practice: A Critical Analysis of Data-Based Studies and Implications for

Nursing Education. Journal of Nursing Education, pp. 488-497.

[12] Seng, T.W. 2001. Measuring Practicum Student Teachers' Reflectivity: The Reflective Pedagogical Thinking Scale. Cited: 24 January 2012 fromhttp://www.ipbl.edu.my/BM/penyelidikan/2001/2001_toh.pdf

[13] Telford, J.K. 2007. A Brief Introduction To Design Of Experiments. Johns Hopkins Apl Technical Digest, Volume 27 (3) , pp. 224-232.