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COMPARISON OF STUDENTS' METACOGNITIVE SKILLS BY GENDER ON CHEMICAL BONDING IN CHEMISTRY

Oleh:

Naseer Ahmed; Senam; Antuni Wiyarsi;
Yogyakarta State University

Article history	Abstract
Submission : 2019-03-18	The main purpose of this research is to investigate the metacognitive skills of students from class 10 th in Bantul and to analyze the comparison between them base on their gender. The method of this research is quantitative descriptive. A questionnaire was used to collect data. The questionnaire was applied in four classes in order to collect data and independent T-test was used to analyze them, the findings proved that generally both male and females use their metacognitive skills in learning. In addition, there are no significant differences between male and female students in metacognitive skills especially in the following domains: knowledge about cognition. The results are discussed in relation and compared with previous researches to show gender differences in chemistry learning and opens the door for future research and educational practice. It is recommended to conduct further research related to gender differences in metacognitive skills using a bigger population.
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Introduction

Chemistry is one of the branches of science that has an important role in the development of science and technology that encourages the creation of quality human resources. Many students encounter difficulties during chemistry learning. There are some topics which need more attention for deliverance of concepts. Metacognitive is divided into two categories: 1) knowledge is cognition which means knowledge of thinking and 2) regulation of cognition (Flavell, 1979), where knowledge of cognition means the ability to monitor learning process or evaluation and conclusion of performance. Metacognitive skills are one of the main suggested types of learning activities that are used in teaching and learning process in chemistry from the last three decades (Zohar & Dori, 2003). Making correct

judgments about some-one's performance and their competence is a metacognitive process that people can use to set their actions towards a successful learning (Hacker, Bol, & Keener, 2008). Chemistry creates an understanding atmosphere, this beautiful world is created. Everything is made of multiples tiny atoms that are closely packed together to give one whole product.

In social meaning, gender is male or female, that includes the construction of identities, behaviors, expectations and power relationships that derive from social interactions (-Uva, Nom, Onyeka, & Jummai, 2008). Indonesia is a vast where female students have full rights to get education. Women's educational achievement in Indonesia got a very significant progress toward equality to men at all levels of education, because of that female students perform well (Buchori &

*Corresponding Author:

Nama : Naseer Ahmed
Lembaga : Chemistry Education
Email : naseerahmed1992@gmail.com

Cameron, 2007). PISA (The Programme for International Student Assessment) reported that girls are performing better than boys in all subjects like science, literacy, mathematics and girls are significantly better in reading as compared to male students. The improvement of girls' performance helped Indonesia to lift its ranking in PISA¹ participating countries. However, the performance of Indonesian students (male and female) in science, mathematics, and reading is one of the lowest among PISA participating countries with an average ranking of 62 out of 69 countries. In the past, a lot of researches were done about male and female comparison in metacognitive skills. PISA gives different levels on the base of performance, level 6 is for level attained by the top performers and level 1 signifies a relatively poor performance. In the results, 75% of Indonesian boys and girls perform at level 1 or lower, it means that Indonesian student's performance level is very low. This gender distinction is widely determined around the world that girls tend to perform more than boys in reading tests.

Metacognitive skills play an important role in learning process. Previous research showed that students who are involved in metacognitive and self-regulation training get higher score in tests rather than those who do not participate in such type of training (Clouse & Alexander, 1997). Although there are many studies related to gender differences in metacognitive skills. Niemi-virta, (1997) reported that male students use mostly apparent learning strategies than females (Bidjerano, 2005) indicated that girls are much better in self-monitoring, planning and goal setting studied gender differences in self-referenced cognitions in mathematics. Self-referenced opinion of individuals which was including their feelings, attitudes, and how much knowledge about students' abilities and skills focuses on the role of cognitions in the most specific areas and in real task situations. They researched on one of the middle school students in the Netherlands and the field of the test was mathematics tasks performance in addition to academic self-concept of mathematics ability. Their results showed that boys scored significantly higher than girls in mathematics tasks and math-related self-concept. However, girls reported that they were

more prepared for their tests and provided more efforts in mathematics task than boys.

Secondary schools teachers' knowledge of teaching chemical bonding whether its covalent or ionic bonding found that they were unaware of the difficulties related to teaching and learning chemical bonding and the main problems related to teaching chemical bonding (Bergkvist, Hjalmarson, & Mägi, 2016). Covalent bonds are parts of abstract chemical matter; students have many misconceptions and lack of knowledge to show a real type of bonding. The student's mistakes or incompetence in solving chemical problems are caused by an error in understanding chemical concepts. Therefore, there is a need of some best techniques that can help students to solve these problems. Metacognitive skills are one of the Higher Order Thinking Skills that are needed in solving chemical problems (Aliyah, Erman, & Sugiarto, 2018). For students of chemistry in secondary schools, chemical bonding is a difficult concept so many students cannot understand basic concept (Rowe, Harms, & Yager, 1978).

Chemistry Learning

In learning there is an understanding of information and skills, someone will learn from teacher, setting (environment) and from alternative factors. Chemistry as a science offers distinctive opportunities to learning, learning in chemistry gives several general skills, e.g. downside determination, thinking in models, being sensitive to and conscious of dangers and hazards. Environmental protection or understanding science contributes to society's property development and concerned in each matter method of life. A number of these skills do overlap with the opposite sciences, some are even on the far side all the sciences, however a number of them also are distinctive to chemistry (Levy Nahum, Mamlok-Naaman, Hofstein, & Taber, 2010).

Having learning objectives in mind should search learning materials by which might simply get access for learning method (Allwright, 2003). Learning activities are a part of learning and in learning activities, there are often several activities like student-centered or teacher targeted etc. Student-centered instruction [SCI] is a tutorial approach during which students influence the content, activities, materials, and pace of learning. Some learning tools improve learning by presenting new info (e.g. texts). As a result, they involve senses that are otherwise uninvolved (e.g. model sets and

¹ Programme for International Student Assessment

3D visualizations). Few tools of learning are helpful but students spend more time on the topic (e.g. textbook issues and on-line homework) (Fleming, 2012). In gender scientific discipline with regard to the reading, male students are thought of higher in science and science and that they thought because the best leader" (Sadker, Sadker, & Klein, 1991).

Gender differences in academic:

On the opposite hand, (Maccoby, 1990) discovered 2 major gender differences, hostility and sympathy. In hostility, there is a clear proof that men scored on top of female within the expression of aggression. With regard to sympathy, even supposing females scored higher than men. However, Black and Wiliam (2005) and Antill (1983) provide a best proof that females has larger capability for social relations and sympathy as compared to male students and ladies are a lot of actuated than boys to perform well in class and obtain sensible grades in school.

By the top of high school, this distinction in course choice makes a measurable distinction in boys' and girls' tutorial performance in these subjects (Davies, Gorard, & McGuinn, 2005). Corbin (1967) explains that male students have a considerably low level of skills in tutorial and conjointly poor tutorial achievement; male students are a lot of possible to go away faculty early, typically with no qualifications. Meanwhile, once there's a time of high education and afterward, feminine students look under-represented within the fields of arithmetic, natural philosophy and computing.

Concepts of Chemical bonding:

Chemical bonding is a vital topic in chemistry as a result of the properties of all substances and their physical and chemical changes that occurred are outlined by the interactions between 2 or more atoms some are covalent bonding and some ionic bonding. By harged particles like ions which is formed by sharing of electrons is ionic bonding (Coll & Treagust, 2003). Thus, chemical bonding is usually instructed by mistreatment models (Nahum et al., 2010). Atoms and molecules are so tiny as a result, human eyes cannot see however atoms or alternative particles are commanded along; here students must perceive models of chemical bonding for understanding basics of chemistry.

The definition of chemical bonding normally is forces between atoms, molecules or particles, and in easy forces that hold atoms

along during a definite and stable geometrical form (Ling & Lagowski, 2013). In other words forces that hold atoms of components along and during a result provide molecules or compound (Christodoulides, Lederer, & Silberberg, 2003). A force between atoms is enough to present building block in crystals (Lewis & Hawley, 2007). Silberberg (2003) explained that forces between 2 atoms that's arise from static force of attractions of 2 opposite charges that is later referred to as chemical bonding. In a chemistry class that is usually instructed by mistreatment models to deliver ideas simply. Previous analysis has shown that students notice several difficulties in chemical bonding to grasp, maybe models that are mistreated to deliver basic ideas of chemical bonding pay necessary role in understanding.

Metacognitive skills in terms of chemical bonding:

Halle et al. (1997) stated that basically a child has the basic knowledge which relates to metacognition and Meta memory, but as the time passes and they get older, their knowledge can be gone. They have to manage their cognitive knowledge and they have to make strategies. To develop better ways to use and to monitor their strategy, and further development of metacognitive knowledge and skills happen in the upcoming years (Alexander & Schwanenflugel, 1996) and (Kuhn, 1999), there is no quantitative information on the development levels of metacognitive skills in different levels of education, for example, between junior high school and senior high school level of education. Several previous studies showed that the best metacognitive skills have very important role and its role in academic life of student is very necessary (Zhao and Mo, 2016). It also makes them able to be creators and self-evaluators in the process of achievements (Zimmerman & Martinez-Pons, 1988) and their performance will be measured accurately (Molenberghs, Johnson, Henry, & Mattingley, 2016).

Understanding of basic concepts in chemistry is still very low. Students have many difficulties in chemical bonding and also they still face difficulties in explaining the chemical properties of compound that based on their chemical structure. For example, many students think that if some liquid compound boils, there is a breakage of covalent bond and they think if there is some solid metal melt, there is also a breakage of covalent bond in simple inter molecular bond between metal atoms. These are

the misconceptions of students (Smith & Nakhleh, 2011). Students low understandings show their low metacognition. Covalent bonds are part of abstract chemical matter. Abstract problem solving often confuses the students. The student's mistake or incompetence in solving the chemical problem is caused by an error in understanding the chemical concepts so that a sharp analysis of covalent bond problem solving is required. Metacognitive skills are one of the higher-order thinking skills that is needed in solving chemical problems.

Against such a background, metacognitive skills are important parts in learning process. The current study would compare male and female student's metacognitive skills by using special topic chemical bonding in one of SMA school in the special region of Yogyakarta, Indonesia.

Research Method

The method of this research was a quantitative descriptive. The main purpose of this research was to check the metacognitive skills on the base of gender, Descriptive studies involves describing the characteristics of a particular situation, event or case.

Sample of Research

The current research is conducted in state senior high schools of Bantul in special Region of Yogyakarta. Because in this region, literacy rate has increased very sharply in recent years (Rukiyati Sugiyo & L. Andriani Purwastuti, 2017) and there is an equal chance to get education for both male and female students. The samples consist of 125 students 'with girls as majority 76 while boys were just 49 from 4 different classes. All students are from class X; the participants were informed about the confidentiality of their responses. They completed the questionnaires voluntarily and they were not offered any reward for their participation during the research.

Research Setting

The main study was completed in four meetings, in each meeting one class was given questionnaire, this metacognitive questionnaire consist topic about chemical bonding to check metacognition of students by distributing questionnaire related to covalent and ionic bonds, in that questionnaire questions were in a statement form each indicators consist of items in given sequence like declarative knowledge eight, procedural knowledge four, conditional knowledge five, planning seven, monitoring seven and evaluation consist of six items.

Specific interest (indicators) was focused to check metacognitive skills of school students on the base of gender whether male is performing good or female and which gender have more metacognitive skills in each indicator.

Research Instrument

A questionnaire was used to check metacognitive skills. All items were written in Indonesia language. The validation of items content, translation into English, and the allocation of items to skills in the metacognition framework were carried out independently by researcher. The development of the questionnaire was done in a multi-stage process that involved validation of the instrument and the translation, the content and allocation to metacognition. The instrument used in this study uses the MAI questionnaire (Metacognitive Awareness Inventory) which consists of 37 statements (Schraw & Dannison, 1994) with answer choices used with a 5 Points Likert-scales ranging from (5) strongly agree, (4) agree, (3) doubtful, (2) disagree, (1) strongly disagree sample is given in Table 1 below.

Table 1. Pattern of questionnaire

No	Statement	Alternative answers				
		SA	A	D	DA	SDA
	I know about what the teacher expects me to learn at school					

Instructions for filling out the questionnaire:

- Carefully read the questions below
- This questionnaire is distributed to find out the metacognitive skills of each student in the class, and does not affect the value of your school academic achievement or report card.
- Answer honestly without looking at your friends' papers, sit down accordingly to your usual conditions
- Give a check list (√) to one of the alternative answers available according to your choices.
- Alternative information answers:
SA = Strongly Agree
A = Agree
D = Doubt
DA = Disagree
SDA = Strongly Disagree

Validity and reliability of the instrument

To analyze metacognitive skills, 6 indicators were used which included knowledge about cognition which consist of declarative knowledge, procedural knowledge, and conditional knowledge. The Regulation about cognition consist of: a) planning, b) monitoring comprehension, and c) evaluating. Questionnaire in this research was MAI (metacognitive awareness inventory). After modification in questionnaire, the instrument was tested for the validity and reliability. It was validated by two chemistry experts from chemistry department (one of the state university of Yogyakarta). In order to check reliability of instruments, instruments were used in two classes after correction instruments applied in four classes to collect data.

Data Analysis technique:

Data analysis technique was independent sample t-test, where it would be comparing male and female metacognitive skills and it will give mean value that can help researcher to compare gender differences in metacognitive skills. There will also analysis on the base of each aspect that will categorize male and female performance in each metacognitive aspect.

Results:

The statistical analysis indicates that students use their metacognitive knowledge and strategies. Table 2 shows that there is no significant difference between male and female students in metacognitive skills of learning.

Table 2. The result of independent samples T-test of students' metacognitive skills

	Levene's test for equality of variances		T-test for equality of means		Conclusion
	F	Sig.	T	Sig. (2-tailed)	
Equal variances assumed	.278	.599	-0.517	0.606	No significant difference
Equal variances not assumed			-0.505	0.615	

The Levene's test for equality of variances showed sig value of 0.599, hence the equal variances assumed exist (sig 0.599 >

0.05) and data is normally distributed. The value of sig (2-tailed) for the equal variance assumed found to be 0.606 > 0.05, thus there was no significant difference of the students' metacognitive values among the boys and the girls.

There were (N=49) male students and (N=76) female. No differences between male and females regarding metacognitive skills seem to occur during the learning process. There was low standard deviation in male students with value 19.740 and female 17.652 and standard deviation difference is also quite less between male and female students meaning there is no significant difference between male and female metacognitive skills (see Table 3 below).

Table 3. Mean score difference between male and female students

	Gender	N	Mean	Std. Dev.	Std. Error Mean
Meta cognitive score	M	49	66.436	19.740	2.820
	F	76	68.189	17.652	2.024

Results of metacognitive score can be seen in Figure 1 (below) which shows the comparison between male and female metacognitive score and it clearly shows that female metacognitive score is higher than male score but there is not so significant difference between male and female score.

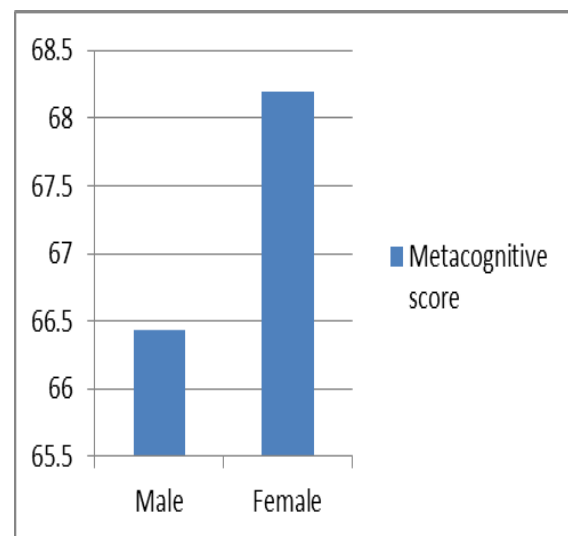


Figure 1. The comparison of male and female metacognitive score

Results on each aspect:

The statistical analysis indicates that students use their metacognitive knowledge and strategies when learning. Table 5 shows there is no significant difference between male and female students in each aspect of metacognitive skills which is declarative knowledge, procedural knowledge, conditional knowledge, planning, monitoring and evolution in learning process. The Levene's test for equality of variances in declarative knowledge showed sig value of 0.824 hence equal variance assumed and data is normally distributed, because (sig 0.824 > 0.05). The value of sig (2-tailed) for the equal variance assumed found to be 0.728 > 0.05, thus there was no significant difference of the students' metacognitive values among the boys and the girls in declarative knowledge. Also, in procedural knowledge there is no significant difference between male and female students regarding procedural knowledge 0.849>0.05. Conditional knowledge 0.953>0.05 showed there is no significant difference between male and female metacognitive skills regarding to conditional knowledge aspect. Planning is 0.694>0.05 as well as in monitoring significant value is 0.268>0.05 indicates that's so there is no significant difference between male and female. Metacognitive skills according to evaluation results showed that significant value is 0.391 which indicates that there is no significant difference between male and female score, after analysis of all aspects related to metacognitive skills researcher came into conclusion that in all aspects of metacognitive skills there is no significant difference between male and female performance.

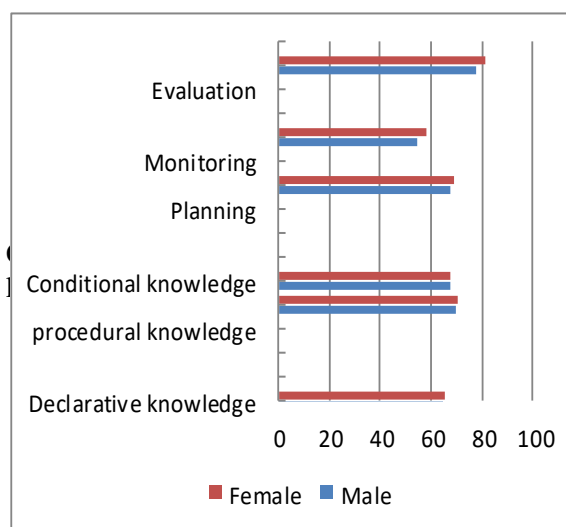
Comparison between male and female student's metacognitive skills according to each aspect can be seen by comparing the means score. There is no significant difference between two genders score according to declarative knowledge, procedural knowledge and conditional knowledge because in each aspect gender have the same mean score and in regulation of cognition each aspect showed results, in planning, monitoring and evaluation, males and females almost have the same mean score which indicates that there is no difference between male and female metacognitive skills.

There was also a low standard deviation in male students and females. It's the second indication that proved no metacognitive difference in chemical bonding between male

and female students. Comparison between metacognitive aspects according to male and female students can see in Figure 4. Given figure shown mean score of male and female students in six aspects of metacognitive skills.

Table 4. Mean score difference between male and female students on each aspect

	Gender	N	Mean	Std. Dev.	Std. Mean
Declarative knowledge	M	49	64.585	19.400	2.771
	F	76	65.532	18.210	2.088
Procedural knowledge	M	49	69.770	22.438	3.205
	F	76	70.477	18.752	2.151
	M	49	67.65	19.661	2.809



Planning	F	76	67.43	20.793	2.385
	M	49	67.857	21.833	3.119
Monitoring	F	76	69.313	18.998	2.179
	M	49	54.518	17.794	2.542
Evaluation	F	76	58.035	16.894	1.937
	M	49	77.976	24.679	3.525
	F	76	81.414	19.737	2.264

There was also a low standard deviation in male students and females. It's the second indication that proved that there is no metacognitive difference in chemical bonding between male and female students. Comparison between metacognitive aspects according to male and female students can be seen in Figure 4, given figure shows mean score of male and female students in six aspects of metacognitive skills.

Figure 2. Graphical explanation of male and female each aspect of metacognitive skills

Discussions and conclusion:

The present study investigated the differences in metacognitive skills between girls and boys, in a sample of high school students. Prior, research reports in conclusive findings regarding the differences in metacognition according to pupils' gender. For instance, Rudman and Glick (2010) and Laurent and Hodges (2009) investigated the gender differences in skills that female have more skills as compared to female students in metacognitive skills (knowledge of cognition and regulation of cognition) and revealed significant gender differences. While in this research, there is no significant difference between male and female students in all six aspects of metacognitive skills. In chemical bonding mostly students have same metacognitive skills with respect to gender. Male and female students had equal metacognitive skills in terms of declarative knowledge, procedural knowledge, conditional knowledge planning, monitoring and evaluation. The same results were also revealed by Niemivirta (1997), Carr and Jessup (1997), Bidjerano (2005), Sezgin-Memnun and Akkaya (2009), and Ozsoy and Gunindi (2011).

This study discovered that the high school students in Bantul, Special Region of Yogyakarta, who participated in this study regardless they are male or female, each class used their metacognitive skills in learning chemistry and especially chemical bonding equally indicated that there is no difference between male and female metacognitive skills. Males and females have the same metacognitive skills in chemical bonding either it is covalent bond or ionic bond hence, metacognition skills test in specific region can be used as an indirect assessment of performance of students during the learning process. This Research showed that males and females both have good metacognitive skills. This is one of the positive points that have influenced the pupils' learning and school performance, since research indicated that the metacognition and self-regulation increase academic learning. Bidjerano (2005), Zimmerman and Martinez-Pons (1990), and Liliana and Lavinia (2011) said that girls are higher than boys in multiple dimensions of metacognition including self-monitoring, planning, and goal-setting while in the current

research, in all aspects of declarative knowledge, procedural knowledge, conditional knowledge, planning, monitoring and evaluation male and female students performed well and there is no significant difference between males and females scores.

As results can be seen from the graphical explanation where it's clearly showed that there is no significant difference between males and females' performance in metacognitive skills as well as in all aspects of metacognitive skills. Based on the results in this research, further research related to the gender differences on different aspects of metacognitive skills is suggested that other metacognitive aspects than the aspects used in this research can give different result there is need of more studies on this topic and research on higher level and different region can give different results. Results of this research conclude in simple words, that in Indonesia, education provided on equal basis and there is no gender difference on the basis of metacognitive skills.

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