Journal of Engineering and Applied Sciences 14 (Supplimentary 01): 8538-8547, 2019
ISSN: 1816-949X

Exploring Pre-Service Chemistry Teacher's Self-Concept in Nanoscience and Nanotechnology using an 8E Learning Cycle

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Abstract: The aim of this study was to analyze pre-service chemistry teacher's self-concept through an 8E learning cycle. The research was conducted with thirty-two pre-service chemistry teachers in a nanoscience and nanotechnology course run by the chemistry education department over one semester. Data collection was carried out using a Chemistry Self-Concept Inventory (CSCI), classroom observation, in-depth interviews and reflective journals that explored the pre-service chemistry teacher's self-concept in mathematics, chemistry, academic, academic enjoyment and creativity. The stages of the 8E learning cycle consists of engage, explore, e-Search, elaborate, exchange, extend, evaluate and explain. The results show that the pre-service chemistry teacher's self-concept was good and the use of the 8E learning cycle engaged pre-service chemistry teachers to understand their self-concept through collaboration, discussion and reflection. In each stage of the 8E learning cycle, the pre-service chemistry teachers reflected on their self-concept based on the principles of individual and social learning. The results show that the 8E learning cycle can be used to help pre-service chemistry teachers understand their self-concept.

Key words: Self-concept, nanoscience and nanotechnology, leaning cycle 8E, chemistry education, observation, individual

INTRODUCTION

Nanoscience is the science of matter that occurs in systems with at least one dimension on the 1-100 nm scale. Nano is about as small as it gets in the world of regular chemistry (although, chemistry can start on the angstrom, i.e., subnanometer scale). Materials science, biology and electronics and nanoscience is thus, strongly related to these research fields and serves as a multidisciplinary interface for all of them. Nanoscience is concerned with the size of matter. On the nanoscale, materials show some unique properties that bulk materials do not have such as quantum-size and surface effects. When the particle size is on the nanoscale, properties such as melting point, fluorescence, electrical conductivity, magnetic permeability and chemical reactivity change as a function of the size of the particle. Nanoscale materials have much larger surface areas than similar masses of larger-scale materials. As the surface area per unit mass of a material increases, a greater amount of the material can come into contact with surrounding materials, thus, affecting reactivity (Bai and Liu, 2013). Nanoscience and nanotechnology are current issues in nanoscale technology development that involves multidisciplinary fields of science. The advancement of science in the ability to synthesize material at the nanoscale provides opportunities for nanotechnology development (Ghattas and Carver, 2012; Tretter, 2006). One of the fields of science that is involved in nanoscience is chemistry.

Historically, chemistry itself has provided a plentiful resource of nanomaterials such as colloids, micelles and polymers. Supramolecular chemistry and chemical self-assembly provide many ways of forming nanostructures and nanosized materials. Chemistry provides a powerful method for the production of the nanomaterials in a controlled manner. On the one hand, chemistry provides the most straightforward methods to generate nanomaterials be it top-down or bottom-up. On the other hand, on account of their high surface area and large surface energy, nanomaterials tend to aggregate and fuse with each other when their surfaces are uncoated, leading to the loss of their unique properties. It is usually necessary, therefore, to modify the surface with functional groups or stabilizers in order to increase the stability and maintain the specific properties of nanomaterials. When we look at nanoscience from a chemical viewpoint, it is not only a matter of size, there are many other factors to

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take into account. Chemistry is the science of the structure, properties and transformation of matter. Significant developments in recent years show that this branch of scientific knowledge has played a crucial role in producing novel materials, developing applications and improving our quality of life. Meanwhile, chemistry is one of the central sciences and contributes to the development of many other scientific fields such as physics, materials science, biology and now a days, nanoscience. Chemistry has contributed to the development of nanoscience and in turn, nanoscience has also, provided many opportunities for chemistry (Bai and Liu, 2013).

As nanoscience and technology continue to grow, there is an increased need to educate a new generation of technicians, scientists, engineers, entrepreneurs, policy-makers, regulators and communicators who are knowledgeable about this emerging field (Jones *et al*., 2013; Yawson, 2010). Technological developments in nanoscience have an impact on the increasing need for expert workers in nanoscience and nanotechnology because there are many jobs involving nanoscience while the experts in nanoscience were not comparable to this growing need (Gilbert and Lin, 2013). Nanoscience education is still in its infancy and unlike other areas of science education, the understanding and research on how to teach the core ideas of nanoscience and nanotechnology are still emerging (Greenberg, 2009). As a result, teachers play an important role in engaging students in current issues, especially with the rapid advancements in science and technology.

Student's competencies keep changing according to, the times. The development of nanotechnology is a major challenge for education today (Jones *et al*., 2013; Roco, 2003). If nanotechnology education is not addressed immediately then there is a risk of slowing the development of scientific and technological advancement (Jones *et al*., 2013). To overcome the challenge, student knowledge needs to be developed by competent teachers. Teachers have competencies that can affect their teaching performance Rahmawati *et al*. (2015). One teacher competency is conceptual understanding. In the Indonesia context, several problems are evident in relation to learning chemistry generally. Linking abstract concepts with student's daily lives contribute to the problem of effective chemistry education. It is expected that students will not only understand chemistry concepts but will also, relate the issues to chemistry and play an active role in solving problems, either in the form of ideas or actions (Rahmawati and Ridwan, 2017). Thus, to achieve these objectives, learning chemistry must be able to be a means of developing student's abilities in their social life; to resolve the kinds of problems that require the chemistry teacher to have a good conceptual understanding and be more creative in applying chemistry to contextual issues in everyday life to create meaningful learning experiences.

Research in effectiveness of learning has traditionally focused on cognitive aspects which include basic abilities such as language, mathematics and science. In addition, to the cognitive aspects, there are other aspects that are as important, namely the affective aspect. Research in the affective aspects of learning can be used to understand the conditions and needs of students in learning, so that, students can developed their understanding and thinking abilities (Ferla *et al*., 2009; Knuver and Brandsma, 1993). This is based on the view that current education reform needs to begin with an understanding of how students learn and how teachers teach (Kim, 2005). Self-concept is a non-cognitive aspect that can be used to understand how students learn and teachers teach (Shavelson *et al*., 1976).

Self-concept is the result of personal self-orientation based on relevant experience that is processed by self-schemes and developed from experience in science (Bong and Skaalvik, 2003). Each individual can be described as having several self-concepts including a chemistry self-concept, a mathematics self-concept, an academic self-concept, a personal academic enjoyment self-concept and a creativity self-concept (Bauer, 2005; Byrne, 1984; Nieswandt, 2007; Shavelson and Bolus, 1982; Wigfield and Karpathian, 1991). Chemistry self-concept is one of the affective aspects from the evaluation process carried out by an individual in chemistry (Bauer, 2008). Every individual has perceptions and beliefs about themselves concerning their achievements and previous experiences in a field of science. Based on these perceptions, the behavior and actions of a student in different learning situations is influenced by how they interpret themselves. Interpretations may include questions about what students can do how they perceive themselves compared to others, how they are seen by other, what they belive they are capable of, how they view they fare in comparison with others, how students feel about themselves and what role students play in the learning context (Bong and Skaalvik, 2003; Nieswandt, 2007). Self-concept is the perception and belief of individuals in a field of knowledge. Student's statements about their capability in chemistry is the part of self-concept in chemistry. The self-concept a student holds will influence their attitude towards chemistry, so, an analysis of student's self-concepts in chemistry, specifically, in nanoscience and nanotechnology courses is essential.

Students who start the learning process with a positive attitude, a strong self-concept and through prior knowledge will find learning easier, grasp concepts faster and achieve at a higher level of success (Chan and Bauer, 2016; Brandriet *et al*., 2013; Zusho *et al*., 2003). This supported by the results of several decades of research on self-concept that concludes that students with a strong and positive self-concept in setting challenging academic goals will endure more challenges, feel anxious, if achievement does not match expectations and enjoy academic activities more (Bong and Skaalvik, 2003; Byrne, 1984; Marsh and Yeung, 1997). Students with a high self-concept towards chemistry have a better understanding than students with a low self-concept (Chan and Bauer, 2016). Student self-concept and their understanding of concepts can be influenced by several things, one of which is the use of a learning model.

One of the learning models that can be used to achieve self-concept competencies is an 8E learning cycle (Rahmawati and Koul, 2016). The 8E learning cycle model was developed from an existing model based on constructivist learning theory where students build understanding based on their initial knowledge (Blank, 2000; Qarareh, 2012). The teacher becomes a facilitator in the learning cycle while students have the opportunity to work in groups, share responsibility and become highly involved during fieldwork. Students also have the opportunity to express their voice which helps stimulate their curiosity about the diversity of ideas held by their classmates, something that rarely happens in classroom-based activities (Rahmawati and Koul, 2016).

The development of an 8E learning cycle model is based on pre-existing learning cycle models and adapted to meet specific needs. The 3E learning cycle proposed by Karplus and Thier (1967) has stages explore, explain and elaborate. The 5E learning cycle proposed by Bybee (1997) has stages engage, explore, explain, elaborate and evaluate while the 7E learning cycle proposed by Eisenkraft (2003) has stages elicit, engage, explore, elaborate, evaluate and extend.

The 8E learning cycle model developed by Rahmawati and Ridwan (2017) has eight stages namely engage, explore, e-Search, elaborate, exchange, extend, evaluate and explain and is therefore, a different learning model from the 3, 5 and 7E models. The 8E learning cycle model involves the use of Information Communication Technology (ICT) through the e-Search stage, training communication and collaboration skills through the elaborate, exchange and explain stages as well as training critical thinking skills through the stages of engage, explore, extend and evaluate. The 8E learning cycle learning model is an appropriate tool to be used for the development of pre-service chemistry teacher's self-concept at the Universitas Negeri Jakarta.

MATERIALS AND METHODS

The research study involved 32 pre-service chemistry teachers in their third-year of study during the 2018/2019 academic year. The purpose of the research was to explore the descriptions, views and explanations about pre-service teacher's self-concepts in the nanoscience and nanotechnology course through the 8E learning cycle. The 8E learning cycle model used in this study was developed by Rahmawati and Ridwan (2017) and takes participants through each of the stages of engage, explore, e-Search, elaborate, exchange, extend, evaluate and explain (Fig. 1).

There are three phases of learning in the 8E cycle. The first phase is personal learning followed by social learning and then reflection. The phases have been identified based on the characteristics of each stage in described Table 1.

After implementing the 8E learning cycle, the researchers looked at and interpreted the self-concepts of pre-service teachers in nanoscience and nanotechnology. Data were generated using the Chemistry Self-Concept Inventory (CSCI) instrument developed by Bauer (2005). The CSCI instrument consisted of 38 questions using a 5 point Likert scale. The CSCI instrument was translated into Indonesian and checked for reliability using the Cronbach alpha reliability measure. Qualitative data were obtained using classroom observation, in-depth interviews and reflective journals.

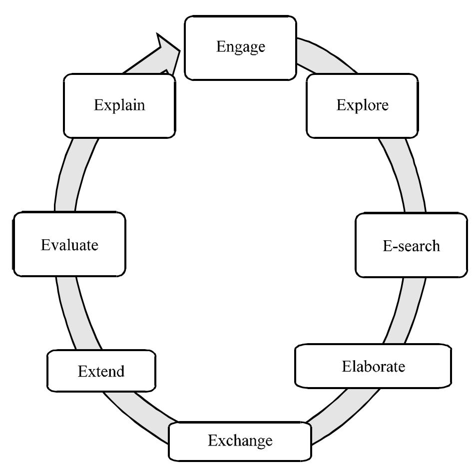

Fig. 1: Stages in the learning cycle 8E learning model

Table 1: The description of learning cycle 8E activity

Stage	Activities
Engage	Pre-service teachers analyzed the issues related to the application of nanoscience and nanotechnology concepts. The issues were provided in an article which was followed by initial questions. The issues related to the unique characteristics and the different properties of nanomaterials that cause the use of nanomaterials in various fields that cannot be applied in macro size such as the different colors of gold nanoparticle with gold in bulk, nanomaterials as a catalyst, gold nanoparticle as a drug delivery system and carbon nanotubes as a material with better conductivity than other metals
Explore	Pre-service teachers explored their initial knowledge of nanoscience and nanotechnology such as the unique characteristics, physical properties and chemical properties of nanomaterials. Pre-service teachers answered questions on a worksheet using their prior knowledge
E-search	Pre-service teachers searched for learning resources to understand the concept of nanoscience and nanotechnology. In this step, pre-service teachers were given the opportunity to access and learn from various learning resources using Information and Communications Technology (ICT)
Elaborate	The pre-service teachers elaborated on their conceptual understanding by comparing their prior knowledge with their understanding after exploring different learning resources
Exchange	The pre-service teachers worked in groups and exchanged their understanding of the concepts
Extend	The pre-service teachers extended their understanding by reflected on the development of their understanding after the exchange stage
Evaluate	The pre-service teachers evaluated their understanding through dialogue and discussions with the lecturer. The pre-service teachers reflected on their understanding and they connected new understanding to the relevant concept
Explain	The pre-service teachers explained their understanding at the end of learning activity. This phase provided an opportunity for pre-service teachers to reflect on their prior knowledge with their new understanding

RESULTS AND DISCUSSION

Self-concept is important for understanding student attitudes to learning and to help students understand concepts. Self-concept is an evaluation an individual makes and customarily maintains with respect to him or herself in general or in specific areas of knowledge (Bauer, 2005, 2008; Chan and Bauer, 2014, 2016). In this study, pre-service chemistry teacher's self-concepts were analyzed. Self-concept in this research included a mathematics self-concept, a chemistry self-concept, an academic self-concept, an academic enjoyment self-concept and a creativity self-concept. Self-concept was analysed using the CSCI instrument developed by Bauer (2005). The reliability of CSCI is demonstrated by its internal consistency based on the correlation between variables using Cronbach's alpha reliability coefficient. Table 2 shows the Cronbach alpha reliability.

The highest alpha coefficient value is indicated by the category of academic self-concept which is 0.850. While the lowest alpha coefficient is indicated by the chemistry self-concept category which is 0.369. Overall, the Cronbach alpha coefficient shows that the instruments used are reliable instruments with alpha reliability scores above 0.50 (Schonborn *et al*., 2015). In addition, the relationship between scales in each of the categories examined through CSCI was known as the Pearson correlation value. The interpretation of the correlation is determined by a significance value (p) that is <0.05. Table 3 shows the correlation between scales in each category of self-concept.

The results of the inter-scale analysis in each category of self-concept show that each scale has a positive correlation. The results of these correlations indicate that there is a one-way relationship between the categories of mathematical self-concept, chemistry self-concept, academic self-concept, academic-enjoyment

Table 2: Cronbach alpha reliability

Categories	Cronbach alpha coefficient
Mathematics self-concept	0.865
Chemistry self-concept	0.675
Academic self-concept	0.575
Academic enjoyment self-concept	0.687
Creativity self-concept	0.811

self-concept and creativity self-concept. In addition, for the distribution of data from student's self-concept which were analyzed using the CSCI instrument, a good self-concept was obtained. Figure 2 shows the data distribution regarding the self-concept of pre-service chemistry teachers in the nanoscience and nanotechnology courses.

Based on Fig. 2, the highest self-concept is found in the chemistry self-concept at 3.63. While the lowest average value of self-concept is in the category of creativity self-concept at 3.46. The chemistry self-concept has the highest average value of all categories showing that pre-service chemistry teachers have a high level of chemistry self-concept. Based on these results, students show a positive perception of self-concept generally. The analysis of student self-concept was reinforced by observations and interviews during the learning process, so that, a qualitative description of the student's self-concepts could be obtained in the nanoscience and nanotechnology courses.

Mathematics self-concept: Mathematics self-concept is an evaluation of individual in mathematics concept (Bauer, 2005). A student's mathematics self-concept has an important role to play in shaping their interests, motivations and understanding of a concept. Based on the data, mathematics self-concepts have a good average of 3.55 with a lowest value of 2.55 and a highest value of 4.64. Based on these results it can be seen that most students have a good chemistry self-concept while some

Table 3: Intercorrelation between scale

Categories	Mathematics self-concept	Chemistry self-concept	Academic self-concept	Academic enjoyment self-concept	Creativity self-concept
Mathematics self-concept	1	0.737**	0.763**	0.776**	0.915**
Chemistry self-concept		1	0.733**	0.819**	0.814**
Academic self-concept			1	0.773**	0.869**
Academic enjoyment self-concept				1	0.857**
Creativity self-concept					1

**Correlation is significant at the 0.01 level (2-tailed). Correlation is significant at the 0.05 level (2-tailed)

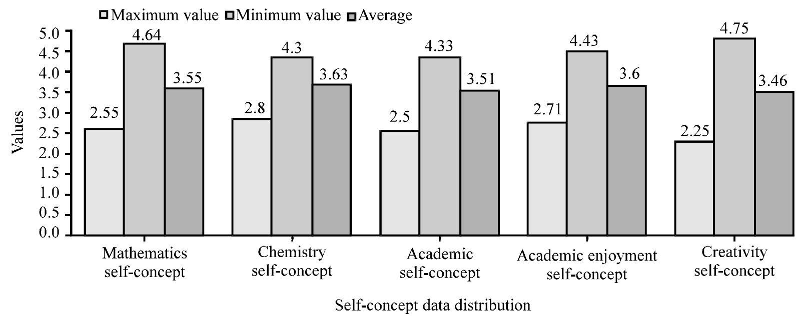

Fig. 2: Data distribution of pre-service chemistry students

students have a poor self-concept. The self-concept of mathematics possessed by students was further, analyzed through observation and interviews to obtain a qualitative description of the data.

> "In this course, I felt difficult to understand the physical properties of nanomaterials. This is because I'm not that good in conceptualize physics and mathematics. For the concepts that required a complex understanding of mathematics and physics, I felt it takes a longer time. However, I realized the problem, so, I had to study harder to understand concepts that needed mathematical understanding." Pre-service chemistry teacher's interview, 13 December 2019

The response above shows that the students has a perception of their mathematical abilities that are not sufficient to understand concepts that require complex mathematical analysis. The results of other interviews show similar effects.

> "I like organic chemistry and inorganic chemistry. I can imagine the bond between atoms in the discussion of organic and inorganic chemistry. But for physical chemistry and analytical chemistry, I don't understand it enough. Because of my low ability in mathematic. It was caused my bad mathematics learning experience when I am in high school."Pre-service chemistry teacher's interview, 18 October 2018

Based on the results of the interview, it can be seen that students have a perception of their abilities in solving mathematical problems and the perception can affected the interests of students. Students who lack ability in mathematics have more interest in fields that do not involved too many mathematical concepts. This result corresponds with the theory that physics concepts can be explained using higher science concepts and mathematical concepts (Jansen *et al.*, 2014). In order to understand the nature of physics in nanoscience and nanotechnology a good mathematical and scientific abilitie is required. Students who have inadequate mathematical concepts will have difficulty understanding the concepts of nanomaterial physics by using complex mathematical logic. Interview results also show that students who have good self-concepts of mathematics can make it easier to learn and understand concepts involving chemistry calculations. The perception that students have about their abilities will make them more confident about understanding a new concept that involves mathematical concepts. Chemistry cannot be separated from the use of mathematical concepts because chemistry and physics concepts in science are explained by using high-level mathematical abilities (Jansen *et al.*, 2014; Nieswandt, 2007; Oliver and Simpson, 1988; Singh *et al.*, 2002). Therefore, as a pre-service chemistry teacher, students need to have a good self-concept of mathematics to better understand the concepts that exist in chemistry to improve teacher competencies.

Chemistry self-concept: Chemistry self-concept is an evaluation of individual in chemistry concept (Bauer, 2005). As pre-service chemistry teachers, students are expected to have good abilities in chemistry. Based on the results of the study, chemistry self-concept is good with the highest average value among all categories of self-concept analyzed. Student's chemistry self-concept had an average value of 3.63 with a lowest value of 2.80 and a highest value of 4.30. These results were reinforced through student observation and interviews, so that, a qualitative description of the chemistry self-concepts in nanoscience and nanotechnology courses were obtained.

> "I felt that my chemistry abilities are good enough. Since, high school, I have loved chemistry and I want to continue my studies in chemistry. I like chemistry because chemistry is quite challenging. When I go to school, my teacher can explain clearly. So, I want to be a good chemistry teacher like my high school chemistry teacher." Pre-service chemistry teacher's interview, 18 October 2018:

Interview results show that students were able to assess themselves with a positive attitude towards chemistry. A positive self-concept of chemistry held by pre-service chemistry teachers occurred because of the learning experiences students had when studying chemistry in high school. Students felt that chemistry was a fun lesson which made them interested in studying chemistry. The formation of self-concepts in the high school aligned with the belief that learning experience greatly impacts on student interest in science. Students who have a positive learning experience tend to have a positive self-concept of chemistry. In addition to the learning experience, the self-concept that students had arose because of the particular environment that supported student learning which influenced how someone responds to a situation related to the science being studied (McConnell *et al*., 2009; Mortimer and Lorence, 1979; Shavelson *et al*., 1976). A positive self-concept enabled students to solve problems that helped them understand concepts better, consistent with the belief that self-concept has an impact on student self-efficacy and attitude enabling them to have a good understanding of self-assessment as a pre-service chemistry teacher. In addition, students with a good self-concept of chemistry have a positive outlook on learning with the 8E learning cycle model.

> "I like the learning cycle 8E Model because in this learning model I was able to explore my understanding at the beginning before I received the concept. My curiosity increased and it made me even more interested in learning." Pre-service chemistry teacher's reflective journal, 25 October 2018

However, students who have low self-concept have the opinion that the implementation of 8E learning cycle required a good understanding of students about the basic concepts of chemistry.

> "This learning model is very interesting but I find it difficult in the beginning it required a good chemistry concept, so that, it can explain the chemistry phenomena in the article but at the initial stage, I need to find out the answers to the questions using the concepts I have. I find it difficult because I realize that I have a low ability, especially, in imagining how was the nanomaterials look like." Pre-service chemistry teacher's reflective journal, 25 October 2018

Interviews showed that students with positive chemistry self-concepts respond better when implementing the 8E earning cycle model. While students who have a poor chemistry self-concept will need more time to adjust to the process at the beginning of learning. Because students already have a low self-concept regarding their ability in chemistry, they don't have the self-confidences to tackle problems that involve chemistry concepts. This is caused by the exploration of student's initial understanding before students get the explanation from the tacher. The degree of self-concept shown by students as pre-service chemistry teachers can indicate their understanding of concepts and the self-efficacy they possess. A teacher or pre-service chemistry teacher, who has a good conceptual understanding and a high self-concept will have greater self-confidence in the learning process, thus, being more likely to provide better teaching opportunities and to implement learning innovations (Guskey, 1988). The openness of student's who have good self-concepts can be seen from the results of interviews with students regarding the implementation of the 8E learning cycle where students who had a positive self-concept developed their understanding through their initial understanding, whilst students with a low self-concept found it difficult to implement a learning model that emphasizes developing understanding through initial understanding. Students with good self-concepts will have the ability to become teachers who have a positive attitude towards chemistry, so that, they can improve the quality and competence possessed by teachers (Holzberger *et al*., 2013; Friedman and Farber, 1992; Skaalvik and Skaalvik, 2010). Based on these results, self-concept as a predictor of the attitudes of pre-service chemistry teachers can developed, so that, pre-service chemistry teachers have good competencies and quality in carrying out chemistry in the classroom.

Academic self-concept and academic enjoyment self-concept: Science as a group of natural sciences has a demand for a comprehensive understanding of all fields of science. One of the fields of science is chemistry. As a pre-service chemistry teacher, things that are learned and understood are not only chemistry concepts but also, the relationship of chemistry to other sciences and education. Pre-service chemistry teachers need to have a good self-concept in the academic field in order to have good competencies. Based on the results of the analysis using the CSCI instrument, the average value for academic self-concept was 3.51 with a lowest value of 2.50 and a highest value of 4.33. While the analysis of academic-enjoyment self-concept using the CSCI instrument obtained an average value of 3.60 with a lowest value of 2.71 and a highest value of 4.43. Based on this, it can be seen that the academic self-concept and academic enjoyment self-concept of pre-service chemistry teachers show positive results. In support of the CSCI program, the results of the analysis of academic self-concept and academic interest were also, analyzed through observation and interviews to obtained qualitative descriptions of the concepts. The description of qualitative data regarding academic self-concept and academic interest can be seen from the following analysis:

> "I really like to get achievements, especially, in academic fields. Therefore, I really like learning, especially learning new things. I have the ambition to be able in the academic field. For that, I try hard to understand everything that I learned during the courses. This is the result of my parent's upbringing which expected their children to go to the highest level of education. My parents always motivated me to achieve and that makes me have great motivation in academic." Pre-service chemistry teacher's interview, 9 November 2018

The interview response shows that the student has a positive academic self-concept and strives to develop academically. The student is motivated because of parents support. This shows that external factors can influence self-concept. Family support is one factor that can influence student motivation and supports the opinion that academic self-concept is strongly related to student achievement (Nagy *et al*., 2006). Students who have a g positive academic self-concept will be more likely to achieve in the fields they pursue. In addition to being motivated to pursue academic matters, students also need to feel comfortable with the academic field they are engaged in. Students who enjoy the academic process and environment will be more motivated in the learning process. An example of the academic enjoyment self-concept can be seen from the following interview.

> "I like chemistry and it makes me feel comfortable and happy in studying chemistry. My interest in chemistry has been around since I was in high school and made me feel motivated and did not have the burden of learning." Pre-service chemistry teacher's interview, 9 November 2018

This response shows that students who have an interest at the beginning of chemistry can learn well and be motivated to learn. This supports the theory that academic interest plays an important role in shaping student learning motivation and in turn, student learning motivation improves student achievement (Ferla *et al*., 2009; Guay *et al*., 2012; Viljaranta *et al*., 2014). One way of developing student self-concept is by using an innovative and creative learning models, so that, learning is not monotonous. One learning model that can improve student's academic interest is the 8E learning cycle as supported by the following statement.

> "The 8E learning cycle really motivates me in learning so my curiosity increases. Because in this method I was invited to process the initial ability, searching, discussion and listening to lecturer's explanations." Pre-service chemistry teacher's interview, 13 December 2018

The statement suggests that the 8E learning cycle model can help promote interest in learning the concepts of nanoscience and nanotechnology. In addition, student answers to questions at the explore stage made them more curious, thereby increasing their interest in learning. According to, Schwartz (2006), this is because contextual phenomena about chemistry, facts and principles are needed to inform the study of the core issues that make up the context. One learning characteristic that increases student's interest in learning is curiosity. Students who show curiosity are more enthusiastic about learning the new things and as a result, achievement can be expected to increase (Cheng *et al*., 2015; Ketelhut *et al*., 2010; Marshall *et al*., 2009). The application of the 8E learning cycle can increase student curiosity, so that, their interest in chemistry increases and self-concepts can be developed.

Creativity self-concept: As pre-service chemistry teachers, students need to be creative. Creativity can be used to solve problems to do with chemistry or other problems in the classroom. Based on the results of the analysis using the CSCI instrument, the self-concept of creativity possessed by chemistry education students can be said to be good with an average value of 3.46 with a lowest value of 2.25 and a highest value of 4.75. This data is supported by the qualitative data from observations and interviews. The creativity of chemistry education students as pre-service chemistry teachers is demonstrated in the following statement.

> "I considered myself to be quite creative. Because in my opinion, a teacher needs to be creative, especially, in terms of preparing for learning to be carried out in the classroom. Teachers need to be able to plan interesting learning in class. Creative learning models can cause the students to feel interested in learning. I can feel the creativity of a teacher when I am in high school. My chemistry teacher usually teaches with different methods and this makes us as students better understand the material. Because of this, then I want to be a creative teacher who is expected to attend by students." Pre-service chemistry teacher's interview, 2 December 2018

This interview response indicates that students are able to assess their creativity in order to become a creative educator. Students realize that a creative teacher is able to liven up the classroom and make students more enthusiast about learning. A creative mindset in students will help develop analytical and creative thinking (Hirst *et al*., 2009; Karwowski *et al*., 2013). Creativity is developed from habits that can be owned by students because it is usually done by them. Creativity in this study refers to problem-solving, perspective and the mindset shown by students in responding to something. Creativity can be formed from experience and also by a habitual way of thinking every day (Silvia *et al*., 2009). Creativity needs to be related to daily activities including the process of learning. The 8E learning cycle model is able to develop student creativity through the learning stages. Learning using the 8E learning cycle involves stages that help students understand concepts using their initial knowledge by looking for the source of learning and through various stages of discussion. Through these stages, students are encouraged to think critically and creatively to understand the concepts.

Student assessment of their self-ability, referred to here as self-concept can indicate the level of confidence students have as pre-service chemistry teachers. As pre-service chemistry teachers, students need to understand chemistry concepts as well as student's interests and creativity, so as to promote a positive attitude towards chemistry and improve student achievement. Therefore, learning needs to be designed, so that, students can develop effectively as a pre-service chemistry teacher. One learning model that can develop effective chemistry teachers is the 8E learning cycle. The model promotes curiosity interest in learning, the development of understanding using initial understanding and creativity and a positive attitude towards chemistry.

CONCLUSION

The students in the study demonstrated a positive self-concept in the category of mathematical self-concept, chemistry self-concept, academic self-concept, self-concept of academic interest and self-concept of creativity. The highest self-concept category was obtained by the chemistry self-concept with a value of 3.63 and the lowest self-concept category was obtained by the creativity self-concept with a value of 3.46. Students who have a good self-concept in learning nanoscience and nanotechnology show better abilities in understanding the concepts of nanoscience and nanotechnology. While students with low self-concepts have difficulty in understanding the concepts of nanoscience and nanotechnology. One of the learning models that can be used to help students understand self-concept is the 8E learning cycle. The use of this learning cycle in nanoscience and nanotechnology courses can enable students to understand the self-concepts they have in mathematics self-concepts, chemistry self-concepts, academic self-concepts, self-concepts of academic enjoyment and creativity self-concepts. An understanding of self-concept can help chemistry education students create a positive attitude as a pre-service chemistry teachers.

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