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Preparing Prospective Teachers in Integrating Science and Local Wisdom through Practicing Open Inquiry

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ABSTRACT

This research aims to determine the ability of prospective teachers in integrating science and local wisdom measured by their ability of preparing teaching materials and learning outcomes. This study used one group pre test-post test design and the participants were 36 prospective science teachers who joined ethno science course. The open inquiry model required prospective science teachers to design and conduct investigations of local wisdom independently. Normality test results indicated that participants were normally distributed. Assessment of the teaching material prepared by participants received average score of 3.6 out of maximum score of 4, so it can be said that the teaching material was in good criteria. The result of t test of pre test and post test indicated that there was difference of pre test and post test result or it can be said that post test result was better than pre test. The research findings consisting of the assessment of teaching materials quality and post test result showed that the preparation of prospective science teacher in integrating science and local knowledge was effective after implementing the open inquiry.

Keywords: Prospective Teacher; Local Wisdom; Open Inquiry.

INTRODUCTION

Education holds a very significant role in assisting students to achieve the required knowledge and skills while it grows and innovates within the curriculum boundaries, in order to obtain previously targeted goals (Topaloglu and Kiyici, 2015). Science learning in primary education curriculum in Indonesia changed the way of its material presentation, from specific material division (biology, physics, chemistry, earth and space) into integrated material. Science learning is presented integratedly because it relates to everyday life. The ideas born from society activities form the basis for integrating knowledge in order to learn to be meaningful (Hewitt, Lyons, Suchocki and Yeh, 2013).

Students are encouraged individually or in groups to actively seek, explore and discover concept. The need to present the science learning integratedly, requires adjustments in preparing prospective science teachers in college. Students as prospective science teachers, need to be trained with the ability to integrate scientific knowledge and indigenous society

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knowledge in the form of local wisdom. Kidman, Yen and Abrams, 2013) recommends to integrate local wisdom with science curriculum, to strengthen students' nationalism sense. Local wisdom in the context of science, is restricted to something that has been applied as a tradition in the community that can be scientifically tested so it can be used as teaching materials.

The diversity of physical and social environments has some potential varieties that can be explored and developed as learning discussion. Physical environment has the potential based on the diversity of flora, fauna and simple application of technology in society that have not been used in learning process. While, society has variety of tradition, habit and value of life that has been used for generations, even in the past it was proven to be able to maintain the environmental balance. Some habits and values sustainably exist and with stand. The encouragement to integrate local wisdom through science learning is implemented because the globalization has significantly shifted the values of indigenous local knowledge in Indonesia. The reality of knowledge value shift shows that local knowledge values might be forgotten. According Baynes and Austin (2012) incorporating cultural knowledge into school curriculum is useful in maintaining citizen identity in a nation.

Prospective science teachers in Indonesia have been prepared to integrate scientific knowledge and local wisdom. A study of the teachers performance in integrating scientific knowledge and local wisdom in the science learning was conducted in 12 schools located in Semarang city, Wonosobo regency and Jepara regency. Those three regions have different characteristics, for example Semarang as metropolitan city has more various cultural backgrounds of students, compared to Wonosobo that is mountainous region with majority of students parents work as farmers, while Jepara is coastal region with most of student parents work as fishermen. Study results showed that science teachers in those regions experienced similar difficulties in linking science as scientific knowledge with local wisdom. Meanwhile analysis of teachers lesson plan documents also showed that they did not have plan to integrate science with local wisdom in teaching activity. The deeper interview of teachers was conducted to discover the root problem and then it was found out that teachers had limited knowledge of integrating science learning and local wisdom but based on the interview teachers were eager to improve their knowledge.

Based on the description of the background, the main problem that can be formulated in this research is How was preparing prospective science teachers in junior high school, to be able to integrate science and local wisdom?. The main problems were then divided into some sub-problems of 1) how was the learning activities of prospective science teachers in Ethno science course through the implementation of open inquiry model ?, 2) how is preparing prospective science teachers, in order to develop science teaching materials that integrate local wisdom after applying the open inquiry model ?; 3) how was prospective science teachers' response regarding open inquiry model ? and 4) was there any differences of pretest and posttest result in Ethno science learning? Therefore the goal of this research was preparing prospective science teachers who will teach in secondary school level, in order to have the ability to prepare teaching materials that integrate science and local wisdom.

Learning activity that aims to integrate the science with local knowledge is important to prepare prospective science teacher, they should experience to conduct authentic and open investigations of local wisdom. Based on Hsu, Roth and Mazumber (2009) finding, scientific inquiry as an authentic experience that shows the involvement of students, has similarities with inquiry method done by scientists. According to Buck, Bretz and Towns, (2008) open inquiry can be applied practically in school or university level. Learning with open inquiry is done by doing investigation, the instructor starts by giving question or problem and background. Open inquiry is appropriate to apply in preparing prospective Science teachers, because the main competencies that should be mastered are research ability to develop teaching materials and strategies. Application of open inquiry for prospective science teachers can develop the independent investigation ability to result in the local wisdom that is scientifically tested. Most of local wisdom in Indonesian society have not proved scientifically and it is resulted the difficulties to integrate it in science learning activity.

Open investigation to test the local wisdom can develop creative thinking skills for prospective science teachers, so they can design and implement it in learning activity. Chinn and Malhotra (2002) said open investigation is needed to develop creative thinking as used by scientists. This is supported by Lee and Butler (2003) that said students involvement and motivation can be improved in science learning after applying open inquiry. According to Zion (2008), learning activities in university level should be able to train students in searching scientific information, finding experimental techniques or procedures and conducting independent scientific testing. Lecturer only needs to direct students to make a tentative conclusion and creates learning activity to be more similar as experts research activities. According to Sadeh and Zion (2012) in an open inquiry, the most complex level is the investigation part because students should formulate their own activities.

Local wisdom in this study is limited to area that become a tradition in the community and deal with to the concept of science that can potentially be tested scientifically. Scientific testing is conducted as a series of investigations. Investigation of local wisdom through experiments is conducted as part of open inquiry stage. The ability of each prospective science teacher in integrating science as scientific knowledge and local wisdom as the original knowledge of the society is measured in this research after applying open inquiry in experimental activity. This activity is meant to test each local wisdom so that it can be adopted as scientific knowledge. The prospective teacher are not only able to investigate the phenomenon, but also capable of designing their own teaching material. According to Gormally, Brickman, Hallar and Armstrong (2009) open inquiry stages consist of; formulating problems, designing, conducting experiments and analyzing experimental results to determine the actions taken independently by the students. Open inquiry gives freedom to students to develop their own discovery procedures, analyze, communicate and draw conclusions. Students might have a chance not only being competent in conducting research, but also deepening their scientific concepts and attitudes. According to Rees, Pardo and Parker (2013) scientific activities for prospective teachers bring impact on the ability of designing to analyzing independently through open inquiry.

The investigation is designed independently, based on the principles of adult learning, while education students or prospective teachers can determine strategy to conduct investigations independently. Students ability to learn is determined by their ability to choose a strategy for comprehending the teaching material, based on the awareness of knowledge that has not been perceived. Tosun and Taskesenligil (2011) said the increasing of students learning outcomes happened because they have strategy to comprehend the materials. Information or materials often used in everyday life are easier to comprehend (Cimer, 2007; Schonborn and Bogeholz, 2009). The information used as study materials, should be able to be scientifically proven through investigation. Investigation activities provide authentic and open experience referring to scientists' work that includes the activity of observing, thinking, investigating and validating. According to Hsu, Roth and Mazumber (2009) scientific inquiry as authentic experience that shows students involvement, has similarities to scientist activity. Experimental activities for prospective teachers bring impact on their understanding and skill to design, implement and evaluate student scientific work. Experience revealed by Lee, Yen and Aikenhead (2012) in ethnographic study of indigenous knowledge recommends that in order to encourage students in conducting investigation that involves a wide range of knowledge, teachers should use students world view as basis for integrating local knowledge and western science.

Science investigation is necessary in order to gain knowledge that is consistent to the scientists method. Analysis stage in scientific investigation can reveal integration between knowledge to improve students learning outcomes, according to of Han, Capraro and Capraro (2014) opinion scientific activities to connect science application is important factor for improving learning achievement. According to Ameyaw (2011) Science integration requires the ability of students to choose the most comfortable learning environment. Students tend to prefer scientific activities that reveal the integration of knowledge, as challenging learning activities. Ankiewicz and Vries (2006) said that teaching science cannot be separated from the societies environments and lives, integrating science and society life requires an organized learning procedure.

The procedure to transform from the indigenous science of society to the scientific knowledge needs conceptualization and reconstruction of new knowledge (Duit and Treagust, 2003). The new knowledge can be obtained through testing the indigenous science, so the truth found is proven as scientific knowledge. The findings of the indigenous science in the form of local knowledge can be formalized into scientific knowledge to enrich science through systematic investigation. Hereditary tradition in society, as source of learning can be used as potential reconceptualization of scientific knowledge. Reconstructed scientific knowledge based on local wisdom is needed, because it has not been scientifically conceptualized textually in teaching materials. According to Meyer and Crawford (2011) Science learning is part of multicultural education because students can be part of daily life that is associated with Science. Society habits provide relevant materials in teaching activity to briefly establishment the assumption facts.

Science learning that integrates local wisdom is considered on the recognition of knowledge as a part of life. Local wisdom revelation for prospective teachers according to science curriculum is learned through learning ethno science course in university level. The objectives of Ethno science course for prospective teachers are important, because it can train them to design and implement learning-oriented to maintain the sustainability of science application to protect the earth and universe. Ethno science is the embodiment of durability and ability that is manifested through a philosophy of life, knowledge and life strategy. If activities undertaken by local society are integrated in the learning of Science, it can answer the problems fulfillment of human life wisely. Modernization in fact can shift the values of local wisdom by foreign knowledge developed so rapidly in the lives Indonesian, both of urban and rural life. The reality is value shift of knowledge frequently results values of local wisdom in order to be forgotten, even in urban areas it has been degraded so the society as knowledge user, is no longer recognize societies indigenous knowledge.

METHODOLOGY

This research applied quantitative method since the required instruments were being tested of their validity and reliability. There was no control variable and the samples were not randomly chosen. After that, the results of operating variables measurement were discoverd by analyzing them statistically using the instruments.

a) Participants

There were 36 participants who intentionally selected from prospective science teachers of Science Education Study Program Semarang State University who joined Ethno Science Course. It was in line with Sugiyono’s statement (2013) that when a research was not intended to generalize certain situation, the researcher can apply the specific and limited sampling technique. There were 36 students joined Ethno science course consisted of 22 females and 14 males and all were targeted as the samples. The amount of participants could not be taken from other places since this course was an exclusive education program of science teacher candidates in Universitas Negeri Semarang.

b) Instruments

The study used five different instruments to collect the data related with the effectiveness of open inquiry model, assessment of teaching materials and activeness in learning, learning results in the form of pre test and post test and student responses. Test material consisted of 25 multiple choice question items with 5 possible answers. The reliability of test was calculated by using KR-20 formula. Teaching material prepared by students was assessed by using assessment instrument with four categories: excellent, good, fair and poor. Student feedback questionnaire consists of 6 statements of Likert scale with four choices of; strongly agree, agree, slightly disagree and disagree. All instruments were self-developed, including the process of deciding the rubrics and constructing the instruments.

c) Research Procedures

This research used one group pre test-post test design Sugiyono (2013). Pre test was given in the beginning of meeting and post test was given in the end of learning process. The design was determined based on the achieved objectives of finding out prospective science teachers' ability to integrate science and local wisdom measured by the ability of compiling teaching materials and learning outcomes. The design can be seen in Table 1.

Table 1. *One Group Pre test-Post test Design*

Pretest	Treatment	Posttest
O_1	X	O_2

The pre test was conducted before the lesson started, while the post test was given right after the learning finished. The course was held using open inquiry model

d) Validity and Reliability Test of Instrument

Open inquiry model has five stages of learning, the reliability and validity instruments were tested. The result indicated that it was reliable because the value of Crombach Alpha was 0.863 and the value of R11 = 0.863> 0.7. The validity of the instrument is presented in Table 2.

Table 2. *Instrument Validity*

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
F1	13.1250	3.983	.660	.541	.828
F2	13.1250	3.850	.721	.595	.811
F3	12.9375	4.329	.582	.508	.847
F4	12.8125	4.296	.598	.475	.843
F5	13.5000	4.267	.839	.708	.794

The correlation of Item-Total Correlation in 5 item stages of open inquiry model obtained the value of > 0, 497. Overall Correlated Value of Item-Total Correlation was > 0.497, so the instrument can be said as valid and can be used for research. Open inquiry model was reliable and valid so it can be used in this research.

Ethno science learning by using open inquiry model was started by choosing and determining the problem by describing general phenomena found in the society based on the concept of science being studied and then it was continued by determining the problems. The information that has been identified was independently used by prospective teachers to design activities of scientific testing through laboratory experiments. Experiments were performed by using simple tools, in order to give them experience of modifying tools because in fact most schools in Indonesia have limited availability of laboratory facility. Students individually designed their own experiment plan in their practice worksheets. The experiment results were analyzed especially of the integration of science and local wisdom, because the result was used as teaching material.

e) Analysis of the Data

The reliability of the data of open inquiry model was analyzed to find out the Crombach Alpha and the value of r_{11}. The validity of the model was measured by finding the value of Correlated Item-Total Correlation. Students' activeness in learning was analyzed by counting active and very active students. The analysis of the ability of science prospective teacher in designing learning material was conducted by measuring the aspect of conformity, depth, broadness and attraction. The learning result was evaluated by comparing the score of pre test with the score of post test, while students' responses were rendered by summing up agree and highly agree answers.

FINDINGS

Learning Activity

Each student individually made observations of general phenomena found in the society to obtain directly the application fact of local wisdom. Students determined the form of local wisdom that was continued to the laboratory testing through experiment. The experiment results was a form of scientific test results, so it was used as teaching materials after being adjusted by science study in school curriculum. Local wisdom that has been tested through experimentation is presented in Table 3.

Table 3. *Test Result of Ethno Science found by Prospective Teachers*

Science	Local Wisdom found by Prospective Teachers	Test Result
Natural Mask	Finger root rice composition has been used from generation to generation as natural mask to protect facial skin.	Rice contains 63% Na to maintain facial skin permeability
Natural Flavoring	Ginger is used to reduce fishy smell in fish and meat.	Mashed ginger produces the aroma to reduce fishy smell.
Pesticide	When the rice turns yellow, pagupon or birdcage is placed in the middle of rice field to scare rats as rice pests.	The effective space of pagupon in rice field to scare rats is between 200-500 m.
Natural dye	Turmeric extract, suji leaf and pandan leaf is used as natural dye in some traditional foods.	Turmeric extract gives yellow color, suji and pandan leaves give natural green color.
Natural Pesticide	Papaya leaves extract can be used as insecticides.	Papaya leaves extract contains papain compound that acts as toxic in caterpillar.
Skin healthy	Rice bran is used as shampoo to cure dandruff problem.	Rice bran contains carbon 1,33%; hydrogen 1,54%; silica 16,98%; and oxygen 33,64% to clean death cell in scalp.

Society tradition phenomena that have been tested scientifically through experiment activities by prospective teachers have resulted on a shift of untested local wisdom to be scientific knowledge. Experiment was done by using simple tools and materials that were easily found in the environment and usable so they can realize that the local wisdom test can be done simply and cheaply. The test results showed that hereditary habit in society is unconsciously seen as a scientific knowledge that can be tested. Prospective teachers can get new and valuable experience through experiment to find the science secret of the endangered past knowledge that have become tradition.

After conducting experiment prospective teachers should present their experiment result. They revealed their steps of experiment started from identifying local wisdom in the society, planning experiments independently, analyzing and compiling reports. They were enthusiastic during the presentation and discussion activity, student assessment results showed 92% of students were very active and 8% were not. Prospective teachers' activeness was in high category, when the learning was conducted through independent and open investigation.

The investigation findings then were adjusted into teaching materials that is suitable for teaching science. Prospective teachers should compile teaching materials and present science material in more contextual way because it was obtained from the result of local wisdom test through experiment by using simple tools and materials. Assessment of teaching materials is shown in Figure 1.

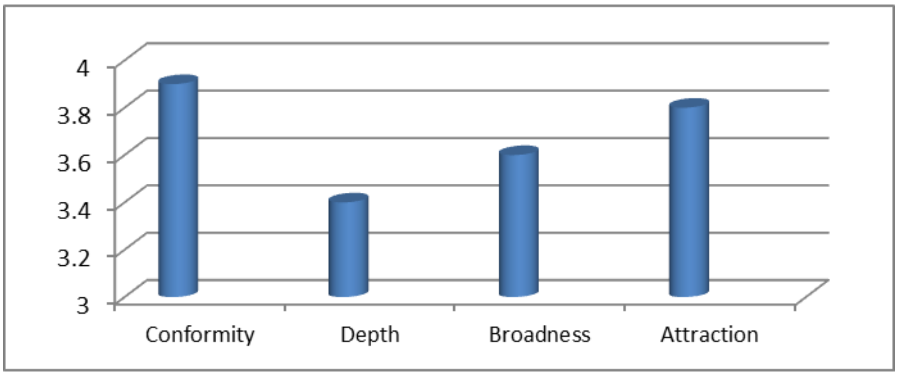

Figure 1. *Assessment of teaching materials*

Compiled teaching materials were assessed by an expert of science. Aspects of suitability was measured based on the basic competencies of students in the curriculum of secondary schools, the level of suitability got a score of 3.8 of maximum score of 4. Description of teaching materials was predicted to reach targeted learning science competencies in school curriculum. Prospective teachers were seen to be able to prepare teaching materials. Aspects of material depth obtained score of 3.3 so the teaching material was considered good to give the knowledge of science for students. Experiment analysis can be well expressed by prospective teachers, so it resulted score of 3.5 in material depth aspect. Teaching materials that provide information of local wisdom obtain score of 3.7 in attraction aspect. Prospective teachers were seen to be able to develop teaching material independently that integrated local knowledge and science through the implementation of open inquiry model.

Students Response

Students response of open inquiry implementation can be seen in Table 4.

Table 4. *Students response of open inquiry implementation in Ethno Science Course*

Statements	Percentage (%)			
	Strongly Agree	Agree	Slightly Disagree	Disagree
Revealing hereditary tradition is important to do in science learning.	94	6	-	-
Science is necessary to be integrated with local wisdom.	81	19	-	-
Prospective teachers need to have ability to design experiment independently.	88	12	-	-
Experiment is needed to test local wisdom scientifically.	94	6	-	-
Test result of local wisdom can be used as teaching material.	81	19	-	-
Integrating science and local wisdom can grow students' nationalism character.	81	19	-	-

All students gave positive responses that stated Ethno science learning is suitable by implementing open inquiry model. The application of that model was proven to be able to train scientific work of prospective teachers, they felt that they had the experience of developing teaching materials after conducting the experiment. Integration problem between science and local wisdom have been overcome.

Pre Test and Post Test Result

Normality test results of pre test data obtained statistical value of 0.973 with sig of 0.880, while post test data obtained statistical values of 0. with sig of 0.993, because the value of sig> 0.05; then it can be said that both the data were normally distributed. Test result of pre test and post test difference test is presented in Table 5.

Table 5. *Pre Test and Post Difference Test*

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre Test-Post test	-23.81250	8.32842	2.08210	-28.25	-19.37	-11.437	15	.000

The result of difference test of pre test and post test obtained t value of 11.437 with the sig of 0.000; because sig = 0.000 <0.05, then it can be said that there was difference in the results of the pre test and post test, or posttest result was better than pretest. Comparison of the average score of pre test and post test is presented in Figure 2.

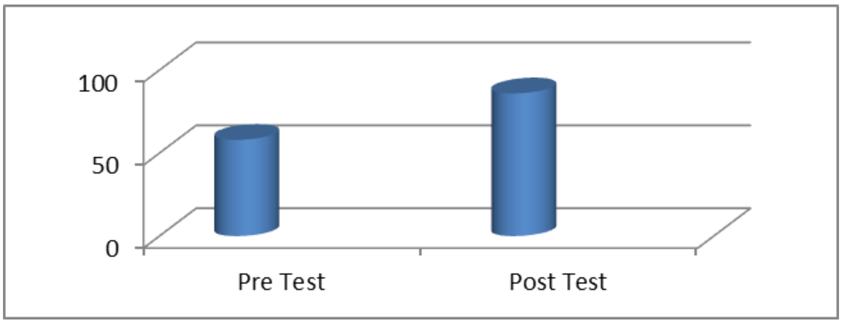

Figure 2. *Comparison of the average score of pre test and post test*

The average of pre test score was 58 and post test was 86, it can be said that the improvement was 28 points. The higher result of post test indicates that prospective teachers have comprehended the learning material of Ethno science. Prospective teachers' understanding of learning material is related to the revelation of local wisdom test in laboratory. Local wisdom or tradition, that was initially difficult to prove scientifically, finally can be tested in the learning process. This finding is parallel to the results of Meij, Meij and Harmsen (2015) when he found interesting learning resources from the environment that can encourage students to learn.

DISCUSSION and CONCLUSION

Prospective science teachers were given the opportunity to carry out scientific investigations on local wisdom. Results of investigation of various traditions in the society have been scientifically tested so it can be used as teaching materials in the science learning. Prospective science teachers looked enthusiastic when presenting their investigation result therefore the results of their activeness assessment showed that 92% was active and 8% was not. Learning environment that applied open inquiry has resulted prospective teachers to have knowledge of the relation between science and local wisdom. The ability to communicate the results of the investigation indicated that prospective science teachers have improved their knowledge based on their investigation findings. Based on Nantawanit, Panijpan and Ruenwongsa (2012) opinion when students are active to present their investigation finding, so it means the findings gave students better understanding of knowledge that is being studied.

Learning by applying open inquiry model has given authentic experience for prospective science teachers. This finding is in line with the finding of Hsu, Roth and Mazumber (2009) that stated scientific inquiry as experience showing the involvement of students has similarities with scientists' activity. According Figure 1, prospective teachers have been able to compile science teaching materials that integrate local wisdom based on the result of investigation that has been carried out. Prospective teachers can be said to have creativity to produce science teaching materials, this finding is consistent with the opinion of Chinn and Malhotra (2002) that said open investigation is needed to develop the students' creativity. Learning activities led to improve the knowledge of prospective science teachers. According to Table 5, the results of the t test value was 11.437 with the sig of 0.000, because the value of sig = 0.000> 0.05, so it can be said that posttest result was better than pretest.

Based on the results of this study it can be concluded that the application of open inquiry model was proven effective to be applied as learning strategy in preparing prospective science teachers to be able to integrate Science and local wisdom. Open inquiry activity has changed the perception of the local wisdom that is previously limited to tradition, become scientific knowledge than can be improved as teaching materials. The conclusion of this research based on Sun and Chee (2013) finding said that when learning model is effective to be applied, it indicates that it is suitable to students' learning styles and characteristics.

The application of open inquiry method invoked self-learning for the prospective science teacher. The preparation of prospective science teacher with a demand of willingness to conduct research was proven to affect the skill of designing learning material. Various local wisdoms were able to be adopted as scientific knowledge through experimental activities. Based on the the research result, the researcher recommend for each science teacher candidates educator to apply open inquiry model because it gives precious experience to students to explore their own knowledge. The self-finding was proven to be able to help students to construct their own integrated science material well.

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Experiential Learning: Its Effects on Achievement and Scientific Process Skills

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ABSTRACT

The purpose of this study is to determine the effects of experiential learning model on student teachers' achievement in chemistry as well as their scientific process skills. The pre and posttest research pattern with treatment and control groups was used throughout the study. While the treatment group received education through experiential learning model, the control group was taught within a traditional teacher-centered approach. The sampling consisted of 40 student teachers studying Chemistry Education at Hacettepe University. Data collections tools were the chemistry achievement test and the scientific process skill test. As the study concluded, experiential learning is an effective approach on academic achievement and scientific process skills. The applicability of experiential learning to high school chemistry curriculum out of teaching curricula rather than those at the universities can be investigated. The impact of experiential learning on other variables can be identified.

Keywords: Achievement; Chemistry Laboratory; Experiential Learning; Scientific Process Skill; Student Teachers.

INTRODUCTION

Learning occurs as a result of experiences and individuals do not always learn in the same way (Yoon, 2000; Kolb, 2000; 1984). To increase the quality of education, learning environments appropriate for individual differences should be created. Differences in general characteristics of students are reflected on their learning processes. Experiential learning theory emerged as a result of taking students' individual differences into consideration. Experiential learning theory depends on studies by Dewey, who takes experiences as basis in learning, Lewin, who emphasizes the importance of students' being active in the learning process, and Piaget, who perceives intelligence not only as characteristics at birth but also as a conclusion of the interaction between the individuals and their environments as well (Yoon, 2000; Kolb, 1984). Experiential learning theory defines learning as a process consisting of four steps. According to Kolb, students should experience four phases of learning when learning a topic. Experiential learning cycle should be structured from concrete experiencing to observation and then from abstract conceptualization to active experimentation (Kolb, 1984). Concrete experiences are turned into abstract concepts within this process and these concepts are used in attaining new experiences.

Experiential learning is considered as an effective way of educational approach. The

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reason for this is the impact of experiential learning on the development of learners' metacognitive skills, enhancing the skills through the implementation of the knowledge to the real situations, and giving the learners the ability of self-learning (Kolb & Kolb, 2006). In experiential learning model, Kolb focuses on experiential learning process rather than routine learning characteristics (Turesky & Gallagher, 2011). It is envisaged in the experiential learning that the validation and internalization of individual change and development are ensured (Healey & Jenkins, 2000). Experiential learning based education requires activities planned appropriate to all learning ways. In general, concrete experience requires full participation of individuals in the activity, while reflective observation requires individuals to develop various perspectives, abstract conceptualization requires attainment of the theoretical knowledge by the individual and active experimentation requires individuals to implement the knowledge. Implementation of the learning cycle in the classroom environment is essential in realization of effective learning (Bahar & Bilgin, 2003; Svinicki & Dixon, 1987). Experiential learning model consist of concrete experience, reflective observation, abstract conceptualization and active experimentation phases. At concrete experience phase, learners require special occasions and examples and to be involved in events. Therefore, topics need to be related to the daily life. Additionally, sample case analysis and role-playing activities should be appropriate to the learning method (Kolb, 1984). Reflective observation is the learning situation where it is important to develop various perspectives by thinking on what is learnt and observed. At this phase, thoughts and opinions about the topic are reflected, the way the facts occur is questioned and certain decisions are made (Kolb, 1984). Reflective observation shall be considered as the phase where various situations emerge at the concrete experience phase is analyzed and solutions for potential problems are sought. At abstract conceptualization phase, on the contrary to learning through concrete experiences, logic, thought and concepts are focused. This phase requires that the theoretical knowledge on the topic should be presented within a certain structure. In this respect, summarizations and explanations made by the teacher would be appropriate (Healey & Jenkins 2000; Kolb, 1984). Active experimentation phase should allow students to learn through implementations and implement what they learn as well. Instead of observing and listening, participating gains importance. Students, who prefer this learning approach, enjoy implementing what they learn and, in other words, seeing that what they learn is useful (Hein & Budny, 2000; Kılıç, 2002; Kolb, 1984). At the first phase of the learning cycle, students have concrete experiences related to the topics. The second phase involves attaining different perspectives towards the gained experiences within a questioning approach. At the third phase, students comprehend the logical structure of what they learnt through their experiences. The final phase of the learning cycle would be the active experimentation.

As learning is a lifelong process and individuals need to learn, interpret or judge situations they experience under various conditions, scientific process skills are very important for significant learning (Bilgin, 2006). Scientific process skills are tools for learning science and understanding scientific studies while setting an essential goal of learning (Anagün & Yaşar 2009). Scientific process skills are listed under three groups as basic skills, experimental process skills and causative process skills (Çepni, 2005). These are not only the skills that are used by scientists in their studies but also are skills that show their effects on individuals' personal, social and global live (Huppert, Lomask & Lazarowitz, 2002). Therefore, using scientific process skills within the experiential learning cycle would ensure the development of basic skills, experimental process skills and causative process skills.

According to the research studies, the most effective and permanent learning in science would be obtained through laboratory method (Bağcı & Şimşek, 1999; Güven & Gürdal, 2002). Laboratory method is the way students follow in learning topics through techniques such as observing, experimenting, learning by doing or presentations in laboratories or purpose-built classrooms (Ergün & Özdaş, 1997). Laboratory studies enable students to participate in activities related to science and experience scientific method, while contributing to development of skills to make observations, produce ideas and interpret topics (Kaptan, 1998). This method also improves individuals' skills like reasoning, critical thinking, developing scientific perspective and problem solving (Serin, 2002). The effectiveness of laboratory applications having such influence on learning science need to be investigated and its impact on different variables need to be determined. Laboratory applications offer the individuals the opportunity of direct contact with the substance world through the help of using the tools, data collection techniques, models and scientific theories (Singer, Hilton & Schweingruber, 2006). Thus, it will be possible for the individuals to learn science and comprehend the scientific studies. Scientific process skills, which facilitate learning, attain research methods, ensure individuals' active participation and responsibility taking in learning as well as increasing permanence of learning, could be developed through laboratory studies in science. The literature review indicates that there are not many studies examining the effect of experiential learning on the laboratory applications, which enable science learners to develop the skills of observation, generating ideas and making interpretations. This study is significant in terms of revealing the importance of chemistry laboratory applications based on the model of experiential learning rather than traditional verification laboratories. Especially, in classes with scientific contents such as chemistry, laboratory method could be used to increase student teachers' achievement levels and improve their scientific process skills. The current study, which has been conducted on this basis, aims to find out the effects of experiential learning model in the chemistry laboratory on chemistry achievement and scientific process skills. In the light of this approach, the aim of this study is to analyze the effects of experiential learning model to be implemented in the chemistry laboratory on student teachers' achievement in chemistry and their scientific process skills.

METHODOLOGY

In this study, which aims to analyze the effects of teaching at the chemistry laboratory through experiential learning model on student teachers' achievement in chemistry and their scientific process skills, was designed within the pre and posttest research pattern with control and treatment groups. Control and treatment groups were determined according to the independent sampling groups' method.

a) Sample

The sampling of the study consisted of 40 student teachers studying Chemistry Teaching at the Faculty of Education at Hacettepe University. The study was conducted within the General Chemistry class. The treatment group was taught through the experiential learning model, while the control group was taught through the traditional teacher-centered model.

b) Data Collection Tools

Chemistry Achievement Test

Student teachers' achievement levels were assessed through the chemistry achievement test developed by the researcher. Chemistry achievement test consists of 15 multiple-choice questions on acids and bases. Reliability and validity studies were done with the participation of 325 student teachers. The achievement test has been administered to the student teachers who are attending science teaching and chemistry teaching programs of the education faculty and have taken the chemistry course. To evaluate the chemistry achievement test, correct answers and wrong answers have been scored as 1 and 0 respectively. The achievement test has been administered to the student teachers who are attending science teaching and chemistry teaching programs of the education faculty and have taken the chemistry course. To evaluate the chemistry achievement test, correct answers and wrong answers have been scored as 1 and 0 respectively. Item analysis was made with the ITEMAN Windows Version 3.50 statistics software and the chemistry achievement test of 15 items with 0.49 average difficulty values, 0.54 average distinctiveness, and the 0.64 reliability coefficient. The literature points out that the item discrimination index of the test is very high (Ebel, 1972), the test comprises of medium difficulty items according to item difficulty index (Özçelik, 1981), and it is at an acceptable level in terms of reliability (Turgut, 1992).

Scientific Process Skills Test

To determine student teachers' scientific process skills, Scientific Process Skill Test (SPST) developed by Okey, Wise and Burns (1982) was used. The test was adapted by Geban, Aşkar and Özkan (1992) into Turkish. It consists of 36 multiple-choice questions. It involves questions assessing skills to define variables in a problem (12), establish and define hypothesis (8), make operational explanations (6), design required analysis on the solution of problems (3), draw and interpret graphs (7). Reliability coefficient of the test is found to be 0.82. The reliability of the adapted version of the test into Turkish was found to be 0.81. Therefore, the test was interpreted as reliable and it was implemented to both control and treatment groups as pre and posttests. For the evaluation of scientific process skills test, correct and wrong answers have been scored as 1 and 0 respectively.

c) Phases of Experiential Process

The applications in the chemistry laboratory have been carried out by using the experiential learning model for the experimental group and the traditional verification laboratory approach for the control group. Experiential learning model applied in the laboratory in treatment group is organized with well-structured activities appropriate to concrete experience, reflective observation, abstract conceptualization and active experimentation. At the *concrete experience* phase, the study made use of the meaning resolution tables prepared on the acids, bases and titration topic. At the *reflective observation* phase, the study lodged activities such as brainstorming and problem solving relevant to the topic. At the *abstract conceptualization* phase of the study, the teacher presented the topics of acids, bases and titration and ensured the relationship between theory and practice with the help of laboratory studies. At the *active experimentation* phase, students implemented their learnt knowledge on acids, bases and titration into various experiments. Students performed their experiments individually. They were provided with feedback by the teacher throughout the experiments, which enabled students to overcome challenges they faced during their experiments and comprehend the relationship between theory and practice.

Traditional teacher-centered laboratory approach has been employed in the control group, and the student teachers have been formerly given the instructions showing detailed information about the aim of the experiment, how to do it and how to analyze the data. The findings of the experiment have been used to verify the notions, principles and laws which have been known previously.

d) Data Analysis

Difference between the pre and posttest scores obtained from the control and treatment groups have been analyzed. During the data analysis, nonparametric tests were used as the number of sampling was below the advised number in the literature and it did not meet the normality assumptions (Green & Salkind, 2008; Leech, Barret, & Morgan, 2005). In analysis of the data, potential difference between control and treatment groups before and after the application was assessed via the Mann-Whitney U-Test. After the experiential learning and traditional teacher-centered learning, the difference between the pre and posttest scores was analyzed through the Wilcoxon Signed Rank Test.

FINDINGS

Chemistry achievement test score averages of treatment group student teachers trained through experiential learning model and of the control group student teachers who were taught according to the traditional teacher-center method were analyzed through the Mann Whitney U-test. According to the analysis results, there is not a statistically significant difference between the pretest scores of control and treatment groups (U=189.50; p>0.05). This conclusion shows that there was no significant difference between the knowledge levels of the control and treatment group student teachers before the application.

The difference between the pre and posttest average scores of student teachers was analyzed according to the Wilcoxon Signed Rank Test. Outcome of the test is displayed on Table 1.

Table 1. *Wilcoxon Signed Rank Test Results of Control and Treatment Groups at the Chemistry Achievement Test*

Chemistry Achievement	N	M	S	Z	p
Treatment Group Pretest	20	3.80	1.44	-3.935	0.000
Treatment Group Posttest	20	8.65	1.87		
Control Group Pretest	20	3.60	1.67	-3.630	0.000
Control Group Posttest	20	6.60	1.98		

Table indicates that the average scores of student teachers obtained from the chemistry achievement test increased after the applications (Z: -3.935; Z: -3.630; p<0.01). These result shows that the experiential learning model applied to the treatment group and the traditional teacher-centered model applied to the control group were effective on the increase in the chemistry achievements of student teachers.

Average posttest scores of student teachers obtained at the end of the traditional teacher-centered or experiential model applications were analyzed through the Mann Whitney U-test.

Table 2. *Mann Whitney U-Test Results of Treatment and Control Groups regarding their Chemistry Achievement*

Chemistry Achievement	N	Rank Average	Rank Total	U	p
Treatment Group Posttest	20	25.90	518.00	92.000	0.003
Control Group Posttest	20	15.10	302.00		

Table indicates that there is a statistically significant difference between the posttest chemistry achievement scores of the student teachers at the control and treatment groups (U=92.00; p<0.05). This result shows that the average scores of chemistry achievement posttest results obtained by the student teachers at the treatment group, who were applied the experiential learning model were higher than those of the student teachers at the control group, who received traditional teacher-centered training and this indicated a statistically significant difference favoring the treatment group.

Data obtained from the scientific process skills pretest in the research were analyzed through the Mann Whitney U-test and there was no statistically significant difference found between the averages of students at the control and treatment groups (U=159.50; p>0.05). This result shows that there is not a significant difference between the scientific process skill levels of teachers at the control and treatment groups before the applications.

The average scientific process skill test scores of student teachers at control and treatment groups were analyzed through the Wilcoxon signed rank test. Findings are displayed on Table 3.

Table 3. *Wilcoxon Signed Rank Test Results on Scientific Process Skills of Treatment and Control Groups*

Scientific Process Skills	N	M	Sd	Z	p
Treatment Group Pretest	20	20.35	3.17	-3.323	0.001
Treatment Group Posttest	20	23.75	3.42		
Control Group Pretest	20	19.05	4.36	-1.559	0.119
Control Group Posttest	20	20.05	3.85		

After the applications average scientific process skill scores of student teachers at control and treatment groups were observed to have increased. There is a statistically significant difference found between the pre and posttest results of student teachers at the treatment group (Z:-3.323; p<0.01). It was seen that he increase in the scientific process skills of student teachers in the control group was not statistically significant (Z:-1.559; p>0.05). This conclusion shows that experiential learning model is essentially effective on improving student teachers' scientific process skills, while the traditional teacher-centered teaching, which was applied to the control group, was not effective.

The average scientific process skills pre and posttest scores of student teachers were analyzed through the Mann Whitney U-test.

Table 4. *Mann Whitney U Test Results of Scientific Process Skills at Control and Treatment Groups*

Scientific Process Skills	N	Rank average	Rank total	U	p
Treatment Group Posttest	20	25.75	515.00	95.000	0.004
Control Group Posttest	20	15.25	305.00		

Scientific process skills of student teachers at control and treatment groups were observed to have statistically significant differences in terms of their posttest average scores (U=95.00; p<0.05). This means that experiential learning model administered to student teachers at the treatment group produced higher scientific process skills posttest scores than that of the control group, who received traditional teacher centered education. This indicates a statistically significant difference favoring the treatment group.

The results of the Wilcoxon Signed Rank Test administered to compare the pre and posttest scores of control and treatment groups at the sub dimension of scientific process skills and the results of the Mann-Whitney U-test administered to compare the posttest scores of the control and treatment groups are summarized on Table 5.

Table 5. *Results of Wilcoxon Signed Rank Test and Mann Whitney U-test related to the Scientific Process Skills Sub Dimensions*

Scientific Process Skills	Group	Pretest		Posttest		Wilcoxon signed rank test		Mann Whitney U -Test	
		M	SD	M	SD	Z	p	U	p
Identifying the variables in the problem	1	4.90	1.83	6.05	2.01	-2.21	0.027	171.50	0.435
	2	4.65	2.01	5.55	2.21	-1.75	0.080		
Establishing and defining hypothesis	1	5.80	1.58	6.70	1.23	-2.16	0.031	165.50	0.335
	2	5.45	1.64	6.30	1.34	-2.55	0.011		
Making operational predictions	1	3.95	1.15	4.75	1.29	-2.19	0.028	100.00	0.005
	2	3.10	1.45	3.35	1.63	-0.54	0.588		
Designing required analysis for the solution of the problem	1	2.05	0.83	2.45	0.69	-2.31	0.021	137.00	0.067
	2	1.60	0.82	1.95	0.89	-1.62	0.106		
Drawing and interpreting graphs	1	3.65	0.99	3.80	0.83	-0.60	0.548	187.50	0.690
	2	3.40	0.82	3.75	0.64	-1.43	0.154		

1: Treatment, 2: Control

Table 7 indicates there are significant differences between the pre and posttest average scores of student teachers at the treatment group in terms of identifying variables in the problem, establishing and defining hypothesis, making operational predictions, designing required analysis for the solution of the problem sub dimensions. Significant differences were observed for the control group in the sub dimension of establishing and interpreting hypothesis. Posttest results of control and treatment group in sub dimensions of the control and treatment groups were compared and a statistically significant difference was found between the posttest scores of two groups regarding the making operational predictions sub dimension.

DISCUSSION

This study investigated the effects of teaching through experiential learning theory on academic achievement and scientific process skills. It is concluded that experiential learning is a theory effective on academic achievement and scientific process skills.

At the experiential learning practice implemented in the chemistry laboratory, student teachers participated in discussions and problem solving activities to develop perspectives towards acids and bases. They attained theoretical knowledge through the explanations and summarizations of the course instructor. They implemented the learnt knowledge by doing experiments at the laboratories for the final phase. Experiential learning model consists of concrete experience, reflective observation, abstract conceptualization and active experimentation phases. Generally, concrete experience requires active participation of individuals in the activity, while reflective observation is the period when they are expected to develop various perspectives, abstract conceptualization is the obtaining of theoretical knowledge and the active experimentation is the implementation of the learnt knowledge. Implementation of the learning cycle in the classroom is essential in realization of permanent and effective learning (Bahar & Bilgin, 2003; Svinicki & Dixon, 1987). Concrete experience, reflective observation, abstract conceptualization and active experimentation phases of the experiential model implemented with materials and activities to the student teachers are seen as the reason for the increase observed in their chemistry achievement levels. The findings of the present study is supported by the related research in the literature which reveal the positive effect of experiential learning on academic achievement, meaningful learning and learning outcomes (Kılıç, 2002; Gosen & Washbush, 2004; Gencel, 2006; McCarthy &

McCarthy, 2006; Ives-Dewey, 2009; Clements & Cord, 2013; Ernst, 2013; McLeod, 2013; Konak, Clark & Nasereddin, 2014; Manav & Eceoglu, 2014; Matuso, 2014).

Looking at the effects of experiential learning and traditional teacher-centered learning on chemistry achievement levels of student teachers, it was found that experiential learning was effective. This conclusion of the study is explained at the experiential learning environments as the emergence of dynamic teaching/learning experiences (Carey, 2007). Experiential learning applications expand the course content and improve students' knowledge levels through real life practice while encouraging students to think effectively and come to conclusions using the data obtained through questioning. Teaching strategies that ensure active participation of students with the help of scientific research such as experiential learning improve conceptual learning more when compared to more passive techniques (Ernst, 2013). Moreover, experiential learning enables learners to make connections between the choices and results (Petrocelli, Seta & Seta, 2013). Experiential learning motivates students for active learning while presenting them the opportunity to think over conceptual situations (Ramburuth & Daniel, 2011). It was determined that Kolb's experiential learning model enabled students to shift themselves from considering knowledge as a series of recognized knowledge towards considering it as a tool for questioning themselves as well as making contributions (Groves, Leflay, Smith, Bowd & Barber, 2013). Individual experiences of learners stand out in experiential learning. Therefore, the role of the teacher has changed from the one who transfers the information to the one who facilitates and organizes meaningful experiences based on the individual needs of the learners (Manolis, Burns, Assudani & Chinta, 2013). As a result of the positive effect of experiential learning on achievement and scientific process, students attain conceptual understanding and effective thinking skills, while bringing dynamic practices to the learning environment and creating the expectation in students to question and contribute.

Kolb's experiential learning model is known to be one of the most effective learning models (Duff, 2004). Learning in the experiential learning model is defined as a process emerging through the transformation of knowledge and experiences (Deryakulu, Büyüköztürk & Özçınar, 2009). Traditional teacher-centered learning and experiential learning models both aim to teach new knowledge to the learners. While traditional teacher-centered learning depends on more abstract and classroom-centered techniques, experiential learning aims to involve students actively in concrete experiences (Stavenga de Jong, Wierstra & Hermanussen, 2006). Experiential learning promotes the association of knowledge and creativity at a high level (Ives-Dewey, 2009). The reason for the effect of experiential learning on chemistry achievement is seen as the active participation of students in concrete experiences as well as the combination of knowledge and creativity.

There is evidence that experiential learning improves advanced learning in addition to changing and improving students' thoughts about themselves (Armsby, 2013). Experiential learning led to changes in students' thoughts about themselves and the learning environment. Students agreed that they understood the implementations of concepts in the real world in a better way, that their interest in the topic improved and that they would remember what they learnt from their experiences in the classroom. Students indicated that with the help of the tasks assigned during experiential learning, their self-confidence levels improved (Cornell, Johnson & Schwartz, 2013). Experiential learning model is found to enable students to be aware of their professional identities, question their own actions and note the importance of their suspicions. Students expressed that experiential learning helped them analyze complex situations deeply while playing an important role in their ways of taking responsibilities or displaying reactions (Pallisera, Fullana, Palaudarias & Badosa, 2013). These changes observed in thoughts of students about themselves are believed to improve their scientific process skills.

Experiential learning process is found to improve students' comprehension of knowledge in depth (Groves, Bowd & Smith, 2010). Experiential learning both provides learning opportunities by thinking and internalizing deeply and ensures learning the knowledge in a more meaningful way (Wu, He, Weng & Yang, 2013). Experiential learning also gives the individuals the opportunity of reviewing the meanings of their experiences and questioning their professional contributions and effects in a critical way (Armsby, 2012). Therefore, the problem solving activities and experiments participated by student teachers during the experiential learning practice are seen as the reasons for their scientific process skills, which consist of identifying variables in the problem, establishing and defining hypothesis, making operational predictions, designing required analysis for the solution of the problem along with drawing and interpreting graphs.

The role of the teacher has changed in today's educational life in either experiential learning model or other teaching activities. This research is important as it enables teachers of the future to know modern teaching activities, learn about the types of activities within this model and implement all these experiences in their teaching profession.

CONCLUSION

The most important factor of an education system is the teacher with no doubt. The effective power of teachers on students and educational programs is stronger than other factors. It is important to improve the qualifications of education faculties and the student teachers studying in these faculties. In this respect, this study planned to serve the aim of improving the qualifications of student teachers and it was found that experiential learning practices at the chemistry laboratory were effective on academic achievement and scientific process skills.

Individual experiences are prominent in experiential learning. Therefore, this study is important as it organizes significant experiences for student teachers in terms of their individual requirements, presents them with the opportunity to think deeply, improves their problem solving and decision making skills and encourages them to implement the new ideas as products of their experiences. Additionally, this study is believed to contribute to the literature by attracting the attentions of students' teachers, motivating them, improving their transferrable skills and preparing them for the following stages of learning.

The current study has been conducted with a sample consisting of prospective chemistry teachers. The effect of experiential learning can also be examined with a sample comprising high school students. The applicability of experiential learning to high school chemistry curriculum out of teaching curricula rather than those at the universities can be investigated. The research about the effects of experiential learning can be carried out in other disciplines as well. The impact of experiential learning on other variables can be identified.

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Effects of the Natural Product Mini Project Laboratory on the Students Conceptual Understanding

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ABSTRACT

This research aims to examine an application of the natural product mini project laboratory in order to improve the students' conceptual understanding. This research was carried out by using quasi-experimental methods. Participants consisted of 31 students of chemistry education department (experimental class) and 28 students of chemistry department (control class) at 6th semester academic year 2012/2013 from one of state university in the West Nusa Tenggara, Indonesia. Experimental class used natural product mini project laboratory model (NP-MPLM) and control class used verification laboratory model. Research results showed that students used the natural product mini project laboratory more conceptual understanding than the students used verification laboratory. The average N-gain of conceptual understanding for experiment class was 0.56 while for the control class was 0.34. The highest N-gain in the experimental class was 0.73 for UV spectroscopy concept while the smallest N-Gain was 0.34 for thin layer chromatography concept. Before the application of the natural product laboratory mini project, the highest percentage of misconception in the experimental class occurred in metabolites category (44.09%) and the highest percentage of do not know the concept occurred in UV spectroscopy (59.68%). After the application of the natural product mini project laboratory, the highest percentage of misconceptions occurred in separation of chemical components (35.48%) and the highest percentage of do not know the concept occurred in NMR spectroscopy (29.03%).

Keywords: The Natural Product Mini Project Laboratory; Conceptual Understanding; Misconceptions; N-gain.

INTRODUCTION

Natural product chemistry (NPC) concepts taught in a hierarchy of complex concepts into simple concept consist of characteristic of secondary metabolites, variation structure, biosynthesis/biogenesis vs molecular structure, structure determination, common properties, synthesis of terpenoids, steroids, polyphenols (polyketides and phenyl propanoid), flavonoids, and alkaloids (Hakim et al., 2012). Most of the NPC concepts consist of the abstract concept. If the students have not reached the level of formal operations, the abstract concept will lead students to misconceptions. This argument is supported by Kazembe (2010) which states that the NPC learning often encounter misconceptions. Misconceptions are often observed in chemistry as well as in the other science disciplines (Kingir & Geban, 2014). In this period of time, several labels were generated to refer to these ideas, such as "pre-conceptions,"

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"misconceptions," "alternative conceptions," and "intuitive knowledge" (Özdemir, 2015). It is necessary to identify the current knowledge of students for eliminate misconceptions which interfere with learning (Harman, 2014).

Piaget (2001) states that knowledge is constructed in the mind of the learner through assimilation and accommodation. Assimilation process occurs when someone complemented the original concept without changed, while the accommodation process occurs when someone changed the original concept to improve it. Adaptation is a balance between assimilation and accommodation. Based on the explanation, misconceptions are generally divided into: the initial concept incomplete and incorrect initial concept altogether. Misconception is difficulty to remove because misconception is a permanent and continuous process (Kazembe, 2010).

Meaningful learning is very important for student (Hakim, et al., 2016; Gunes, et al., 2015; Bezen, et al., 2016). Laboratory activities can make meaningful learning by improving students' conceptual understanding and overcoming misconceptions (Hakim, et al., 2013; Roth, 1992). The students will achieve meaningful learning by forming a link between the new information and the existing information.

This research aims to examine an application of the natural product mini project laboratory in order to improve the students' conceptual understanding.

METHODOLOGY

This study uses a quasi-experimental research with a nonequivalent control group design (Cresswell, 2007). Participants consisted of 31 students of chemistry education department (experimental class) and 28 students of chemistry department (control class) at 6^{th} semester academic year 2012/2013 from one of state university in the West Nusa Tenggara, Indonesia. Experiments class used the natural product mini project laboratory (Hakim, et al., 2016) and control class used verification laboratory.

The natural product mini project laboratory begins with a problem to be solved by the students. The problem is "how do you isolate one of the secondary metabolites of a leaf from *Artocarpus altilis*, heartwood from *Hopea odorata*, a rhizome of *Curcuma xanthorrhiza*, a rhizome of *Kaemferia pandurata*, a rhizome of *Curcuma aeruginosa*, and rind, pulp, and seed of *Cassia grandis* to be studied further?".

Structure of the natural product mini project laboratory consist of (Hakim, et al. 2016): (1) Laboratory activities training (Students practice in groups, 3-4 students per group, to isolate a secondary metabolite from the rhizome of *Curcuma longa*), (2) Orientation problem (Students were given the problem. Each group worked on one plant sample. Plant samples consist of a leaf from *Artocarpus altilis*, heartwood from *Hopea odorata*, a rhizome of *Curcuma xanthorrhiza*, a rhizome of *Kaemferia pandurata*, a rhizome of *Curcuma aeruginosa*, and rind, pulp, and seed of *Cassia grandis*), (3) Designing laboratory activities (Students undertook a literature review of various sources and made proposals for experiments), (4) Presenting laboratory activities proposal (Students communicated proposals to the other groups through a presentation), (5) Implementation of laboratory activities (Students implemented their proposal and collected data from sample preparation, extraction, fractionation, and purification of secondary metabolites), (6) Results reporting & presentation (Students made a report of their investigation and communicated it to other groups through presentations), (7) Evaluation of the laboratory activities and analysis of the complex concepts (Students evaluated the laboratory activities that have been performed. Students infer complex concepts from information that has been obtained during laboratory activities such as secondary metabolite nomenclature, common properties of secondary metabolites, characteristics of secondary metabolite structures, separation of chemical components, and identification of secondary metabolite structures).

The natural product mini project laboratory provides opportunities for students to design their own activities to isolate secondary metabolites. Students design procedures for isolate secondary metabolites from plant samples that have not been reported in other natural product laboratory experiments (Halpin, et al., 2010; Walsh, et al., 2012; Nazri, et al., 2012; Carroll, et al., 2012).

Table 1. *Example Question of The Precondition Test*

Questions	Answer
How to improve efficiency of the maceration extraction? a. Sample surface area is enlarged b. Reduce the amount of solvent c. Reduce the amount of sample d. Container extraction is enlarge e. Increase the amount of solvent Reason .... Degree of Certainty: 0 1 2 3 4 5	A Reason: Enlarge the sample contact with the solvent can be done by increasing the surface area of the sample

Table 2. *Example Question of The Natural Product Chemistry Concept Test*

Concepts	Questions	Answer
Metabolites categories	A compound can be classified into the categories of primary metabolites if they meet the following criteria EXCEPT .... a. It is formed through the main metabolic pathways b. The main constituent in every organism c. It is found the same in every organism d. It is necessary for the existence of an organism e. It is used by organism to defend itself Reason: a. Primary metabolites are not formed through primary metabolic process b. Primary metabolites are not directly used for growth c. Primary metabolites are not used as a basis of growth of organisms d. Primary metabolites are not involved in the process of reproduction of organisms e. Primary metabolites do not play a role in the process of environmental control Degree of Certainty: 0 1 2 3 4 5	E Reason: e

Experimental class used natural product mini project laboratory model (NP-MPLM) and control class used verification laboratory models. The instruments used are precondition test containing 15 questions and natural product chemistry concept test containing 35 questions. The forms of test used modified CRI technique (Hakim, et al., 2012). Example guestion of precondition tes and natural product chemistry concept test can be seen in Table 1 and Table 2.

The validity of the instrument is determined by using content validity experts. The instrument has also been tested for validity and reliability by 34 students who have enrolled natural product chemistry course in the previous year. Reliability of test scores estimated from Kuder-Richardson formula 20 (Cohen, et al. 2013). The reliability of each test is 0.83 and 0.99 for the precondition test and natural product chemistry concept test respectively.

Data processing is done by calculating the normalized gain scores and test two mean differences (t test or Mann-Whitney test). Percentage understand concepts, misconceptions, and do not know the concept was analyzed with the following provisions modified CRI (Hakim, et al., 2012)

Table 3. *Terms CRI Modified for Each Answer Given*

Answers	Reasons	CRI value	Description
True	True	> 2.5	Understand the concept of well
True	True	< 2.5	Understand the concept but are not confident with the answers given
True	False	> 2.5	Misconceptions
True	False	< 2.5	Do not know the concept
False	True	> 2.5	Misconceptions
False	True	< 2.5	Do not know the concept
False	False	> 2.5	Misconceptions
False	False	< 2.5	Do not know the concept

FINDINGS

The NPC Conceptual Understanding

The study involved eleven concepts that can be applied in natural product chemistry laboratory consisting of: metabolites categories, function of secondary metabolites (SM), structure of SM, characteristic of SM, nomenclature of SM, isolation of SM, separation of chemical components, thin layer chromatography (TLC), UV spectroscopy, IR spectroscopy, and NMR spectroscopy.

The highest increase students' mastery of the concept in class control occurred in function of SM by 51.15% (medium category) and the lowest increase occurred in the separation of the chemical components by 17.47% (poor category). In the experimental class, the highest increase occurred in UV spectroscopy at 72.85% (high category), while the lowest increase occurred in thin layer chromatography of 34.35% (medium category).

Table 4. *The Score of Natural Product Chemistry Laboratory Concepts*

Concepts	Experiment class %			Control class %			Λ N-gain
	Pretest	Posttest	N-gain	Pretest	Posttest	N-gain	
Metabolites categories	30.82	78.49	66.94	32.97	55.20	40.40	26.54
Function of SM	37.63	77.06	63.98	33.69	62.01	51.15	12.83
Structure of SM	36.20	97.49	42.65	35.48	73.12	27.29	15.36
Characteristic of SM	28.23	73.66	57.48	29.03	51.34	35.88	21.60
Nomenclature of SM	33.87	80.11	71.51	33.33	55.91	38.07	33.45
Isolation of SM	29.17	73.92	63.02	28.76	53.49	39.55	23.47
Separation of chemical components	24.37	68.10	54.40	25.81	36.56	17.47	36.93
TLC	25.27	53.23	34.35	20.43	53.76	39.95	-5.60
UV spectroscopy	34.41	87.63	72.85	37.63	61.29	32.47	40.38
IR spectroscopy	35.48	79.03	53.87	32.26	53.23	19.03	34.84
NMR spectroscopy	26.88	53.23	37.96	30.65	50.54	30.59	7.37
Average	31.12	74.72	56.27	30.91	55.13	33.80	22.47

The highest difference between the experimental class and the control class happened to separation of chemical components and UV spectroscopy concept, while the lowest difference occurred in thin-layer chromatography concept. The average n-gain experiment class was 56.27% and control class was 33.80%. It showed that used of the natural product mini project laboratory more effective in improving natural product chemistry laboratory concepts.

Statistical calculations such as normality test, homogeneity, and the mean difference test of improved natural product chemistry laboratory concepts of the experiment class and control class is presented in Table 5. Test two mean differences students conceptual understanding was a significant differences between the experimental class and the control class that occurred in the concept of secondary metabolites structure, secondary metabolites characteristic, isolation of secondary metabolites, separation of chemical components, UV spectroscopy, and IR spectroscopy with a experiment class superior than control class

Table 5. *Statistical Calculations Students' Mastery of Natural Product Chemistry Laboratory Concepts*

Concepts	Normality test (α = 0.05) Sig. Exp	Sig. Cont	Explan. Exp	Explan. Exp	Hom (F)	t test or Mann-Whitney test (α = 0.05) t or U	p	Explan.
Metabolites categories	.000	.000	Not normal	Not normal	Not hom (0.015)	u=333.50	.108	Not sig.
Function of SM	.000	.000	Not normal	Not normal	Hom (0.953)	u=390.50	.488	Not sig.
Structure of SM	.033	.060	Not normal	Not normal	Hom (0.972)	u=287.50	.025	Sig.
Characteristic of SM	.043	.001	Not normal	Not normal	Hom (0.162)	u=296.00	.035	Sig.
Nomenclature of SM	.000	.000	Not normal	Not normal	Hom (0.081)	u=287.50	.170	Not sig.
Isolation of SM	.285	.233	Normal	Normal	Hom (0.210)	t=2.881	.006	Sig.
Separation of chemical components	.023	.001	Not normal	Not normal	Hom (0.233)	u=180.50	.000	Sig.
TLC	.052	.001	Normal	Not normal	Hom (0.290)	u=376.50	.373	Not sig.
UV spectroscopy	.000	.000	Not normal	Not normal	Hom (0.837)	u=232.00	.001	Sig.
IR spectroscopy	.000	.000	Not normal	Not normal	Not hom (0.006)	u=266.50	.006	Sig.
NMR spectroscopy	.000	.000	Not normal	Not normal	Hom (0.498)	u=403.50	.626	Not sig.

Percentage of understand concepts, misconceptions and do not know the concept of modified CRI data analysis can be seen in Table 6. The result of pretest shows that the highest of misconception in the experimental class occured on metabolites category (44.09%), while the highest pretest of misconception in the control class occured on structure secondary metabolites (33.84%). The highest pretest percentage of do not know concept in the experiment class occurred on UV spectroscopy (59.68%), while the highest pretest percentage of do not know concept in control class occured on separation of chemical (53.57%).

The highest posttest percentage of misconception in the experimental class occured on separation of chemical components concept (35.48%), while the highest posttest percentage of misconception in the control class occured on nomenclature of SM (32.14%). The highest posttest percentage of do not know concept in the experiment class occurred on NMR spectroscopy concept (29.03%), while The highest posttest percentage of do not know concept in control class occurs on isolation of SM concept (34.52%).

Table 6. *Percentage Recapitulation of Understand Concepts, Misconceptions and Do not Know Concept*

Concepts	Experiment class						Control class					
	Pretest			Posttest			Pretest			Posttest		
	U	M	D	U	M	D	U	M	D	U	M	D
Metabolites categories	0.43	4.09	5.48	5.27	9.35	.38	8.57	2.14	9.29	9.52	3.81	6.67
Function of SM	4.73	7.63	7.63	6.34	5.05	.6	6.19	9.76	4.05	9.05	0.24	0.71
Structure of SM	8.95	3.47	7.58	0.56	8.95	0.48	3.21	8.84	7.95	7.14	5.00	7.86
Characteristic of SM	3.39	1.45	5.16	1.77	7.74	0.48	7.68	5	7.32	0.71	0.54	8.75
Nomenclature of SM	0.97	8.71	0.32	5.81	7.74	.45	6.79	5.71	7.5	7.14	2.14	0.71
Isolation of SM	8.28	1.18	0.54	6.67	4.73	.60	9.05	4.52	6.43	5.71	9.76	4.52
Separation of chemical components	2.90	3.87	3.23	1.61	5.48	2.90	6.07	0.36	3.57	5.36	6.07	8.57
TLC	9.35	2.26	8.39	9.35	5.32	5.32	5	1.25	3.75	2.68	4.11	3.21
UV spectroscopy	0.97	9.35	9.68	3.87	.06	.06	5.71	9.64	4.64	6.07	0.71	3.21
IR spectroscopy	2.26	0.97	6.77	9.03	.45	4.52	3.93	7.86	8.21	8.93	.93	2.14
NMR spectroscopy	9.35	7.42	3.23	6.77	4.19	9.03	3.21	6.79	0	1.79	7.86	0.36
Average	1.05	1.85	7.09	9.73	8.46	1.80	5.95	9.26	4.79	6.74	0.83	2.43

U = Understand Concepts
M = Misconceptions
D = Do not Know Concept

DISCUSSION

Implementation of the natural product mini project laboratory can increase the conceptual understanding of NPC concept better than verification laboratory. The implementation of laboratory activities give the student opportunity to design their own experiments will provide a significant challenge for learners (Hakim, et al., 2016; Hartings, et al., 2015; Çibik & Yalçin, 2013). Through this challenge, students will be motivated to study the books and collecting information from other sources which will further help the students understand the implemented concepts in practical activities.

The highest percentage n-gain of the experiment class occured in UV spectroscopy (72.85%) and the lowest percentage n-gain occured in thin layer chromatography (34.35%), while the highest highest percentage n-gain of the control class occured in function of secondary metabolites (51.15%) and the lowest percentage n-gain occured in the separation of the chemical components (17.47%). Our analysis of the results is based on the argument that the students implemented the natural product mini project laboratory are given the opportunity to determine its own structure of isolated compounds based on UV, IR, and NMR spectra. From the three kinds of spectroscopy, UV spectroscopy is the most simple and easy to understand. The control class determined the structure of isolated compounds based on UV, IR and NMR spectra of standard compounds, so the control class just compared spectra data with the structure of standard compounds.

The students studied NPC often encounter misconceptions (Kazembe, 2010). This is in line with the average pretest results that showed a high percentage of misconceptions in both class. After the learning process, the misconceptions percentage decreases with experimental class (18.46%) and control class (20.83%). Learning is performed on both classes using the laboratory activities. The results are consistent other reseachs that laboratory activities reduce misconceptions (Prilliman, 2012; Setyadi & Komalasari, 2012).

The result of pretest showed that the highest misconception had occured in the experimental class for metabolites category (44.09%), while the highest pretest percentage in control class of misconception had occured for structure of secondary metabolites (33.84%). The highest pretest percentages of do not know concept occured in experiment class for UV spectroscopy (59.68%), while the highest pretest percentages of do not know concept occured in control class for the separation of chemical component (53.57%). The result can be caused by differences in the learning experience of students. The experiment class derived from chemical education courses and control class from chemical studies program.

The result of posttest showed that the highest misconceptions in experimental class had occured in separation of chemical components (35.48%), while the highest posttest percentage of misconceptions in the control class had occurred in nomenclature of secondary metabolites (32.14%). The highest posttest percentage of do not know concept in the experiment class occured in NMR spectroscopy (29.03%), while the highest posttest percentage of do not know concept in the control classes occurred in isolation secondary metabolites (34.52%). This is understandable because the concept of chemical separation involves the experience of students to separating secondary metabolites from samples in laboratory stage. Separation of secondary metabolites followed a complex series with differentces of secondary metabolites properties. This could potentially lead students to misconceptions. Nomenclature of secondary metabolites that have a high percentage of misconceptions on the control class can be caused by secondary metabolites nomenclature not followed the IUPAC but by trivial naming. This is due to the structure of secondary metabolites that are relatively large thus causing systematic IUPAC name is too long for secondary metabolites.

NMR spectroscopy remains elusive for learners because the concept is relatively complex (compared to UV and IR spectroscopy). Secondary metabolite isolation was difficult to understand by students from control class. The students used verification laboratory only followed the specified procedures in the laboratory manual, so no chance for student to try different alternatives in conjunction with the isolation of secondary metabolites. Analysis of the verification laboratory activities suggests that no meaningful learning takes place in the verification laboratory (Hartings, et al., 2015; Burand & Ogba, 2013; Domin, 1999).

CONCLUSIONS

Students conceptual understanding who using the natural product mini project laboratory was significantly higher for the structure of secondary metabolites, secondary metabolites characteristic, isolation of secondary metabolites, separation of chemical components, UV spectroscopy, an IR spectroscopy than students who using verification laboratory. Before learning process the highest percentage of misconceptions occurred in the experimental class for metabolites category (44.09%) and the highest percentage of do not know occurred in on UV spectroscopy (59.68%), and after learning process the highest percentage of misconceptions occurred in the experimental class for separation of chemical components (35.48%) and the highest percentage of do not know concept occurred in NMR spectroscopy concept (29.03%).

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Pre-Service Science Teachers' Conceptions of Systematics and Taxonomy

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ABSTRACT

This study aims to examine the pre-service science teachers' conceptions of Systematics and Taxonomy. Sample of the study consists of 54 preservice elementary-science teachers enrolled in a compulsory General Biology course. Groups were asked to classify 100 representatives of traditional phyla and kingdoms before the subject of Classification of Life's Biodiversity was presented. While the subject matter was being presented, participants were required to identify their mistakes, and write reflection papers addressing the reasons for these mistakes. Data were analyzed through qualitative data analysis techniques. Findings revealed that the preservice teachers' earlier school experiences did not help them to overcome their tendencies to utilize intuitive folk taxonomy and/or analogue comparison, and semantic similarities as their main criteria of classification.

Keywords: Classification; Conception; Preservice Science Teachers; Systematics; Taxonomy.

INTRODUCTION

Systematics and Taxonomy, the sub-disciplines devoted to naming and classifying living organisms, are central to biological sciences. They organize and structure scientific reasoning across a wide range of sub-disciplines from evolution and ecology to anatomy and physiology (Yen, Yao & Mintzes, 2007). Despite this essential role in organizing understanding of biological diversity, a number of investigations demonstrated lack of taxonomic knowledge and ability to identify organisms not only by the general public but also by the educated scientists (Leather & Quicke, 2009). Besides, the preconcepts of living organisms pupils constructed in everyday life do not always correspond to biological ones. Worse still, such conceptions are resistant to change (Wasmann-Frahm, 2009).

'Systematics and principles of taxonomy' is a part of elementary science and secondary school biology curricula in Turkey. Formal curricula intend all students to learn about classification systems that categorize species into recognized taxonomic groups starting from the early grades. Yet, despite all the explanations in the formal curricula, little is known about how Turkish students understand, use and learn taxonomy. There is no particular study exploring the ways taxonomic issues were taught in Turkish schools, either. Although taxonomy is integrated to teacher education programs in Turkey, little is known about how primary and secondary school teachers are trained to deal with taxonomic issues.

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This study aims to examine the Turkish pre-service science teachers' conceptions of systematics and taxonomy. It is assumed that the teachers' knowledge and instructional preferences have a potential influence on the way these subjects are learned (De Fina, 2003). Examination of preservice teachers' conceptions is therefore significant to identify their probable misconceptions and inadequate knowledge about systematics and taxonomy. This way, transfer of preservice teachers' probable misconceptions to future students can be avoided. When the sources of preservice teachers' inadequate knowledge are addressed and difficulties in understanding and applying taxonomic principles are identified, better strategies to teach systematics and taxonomy can also be developed. The research question guiding the study was:

- How do Turkish preservice science teachers classify the living things?

Knowledge of Systematics and Taxonomy

The modern system of classification, the so-called Linnaean Taxonomy, uses common evolutionary relationships and morphological similarities to bring order to over 2.5 million known species of plants and animals. Yet the intuitive folk taxonomy (Halverson, Pires & Abell, 2012) and the analogue comparison (Eichberg, 1972; in Wasmann-Frahm, 2009) are based on overall similarity and one or two isolated common properties by a very subjective view depending on the context (Kinchin, 2000). For instance, the common idea that 'penguins, whales and sea-lions are fish' reveals a classification based on habitat and locomotion criteria (Wasmann-Frahm, 2009). Intuitive folk taxonomy would separate reptile and birds. Crocodiles would be grouped with lizards and turtles based on reptilian characters. On the other hand, modern phylogenetic classification place crocodiles with birds based on shared common ancestry (Halverson, Pires & Abell, 2012). Although both intuitive folk taxonomy and analogue comparison may trigger such misconceptions, they are not the sole reasons of errors in classification. A wide range of experiential differences, linguistic factors, conceptual problems and limitations in logical reasoning ability can also cause errors in classification (Yen, Yao & Mintzes, 2007).

Multiple misconceptions have been reported in the literature related to the knowledge of systematics and taxonomy. The most important findings of a recent study by Yen, Yao and Mintzes (2007) indicate that for most students, the concept label animal refers to vertebrates especially to common, well-known mammals and birds. Students also tend to use external morphology, habitat and movement in distinguishing vertebrates and invertebrates. Tunnicliffe and Reiss (1999) indicate that pupils of all ages mainly recognize and use anatomical features when naming the animals. However, as pupils age, their reasons for grouping animals become more complicated that they begin to show evidence of an embedded taxonomic knowledge. For instance, older pupils are more likely to also use behavioural and habitat attributes to group animals. Similarly, Kattmann (2001) report students' preference to classify creatures along the criteria of habitat and locomotion. Kattmann (2001) points to students' tendency to continue using these criteria even after learning the categories of biological taxonomy.

Yen, Yao and Mintzes (2007) quote early works by Bell (1981) in New Zealand, Ryman (1974) in the United Kingdom and Trowbridge and Mintzes (1985, 1988) in the United States that also revealed children's difficulty in classifying vertebrate and invertebrate animals into their appropriate taxa. Habitat and external features such as the presence or absence of appendages, the texture of the body surface, and the size of body parts, were used as visual cues for classification. Bell (1981)'s study also provided evidence that individuals of all ages and educational backgrounds subscribe to a narrow, "restricted or everyday idea" of the concept animal and use it in reference to pets and common "barnyard and zoo" creatures, especially to large mammals possessing four legs and fur, and making audible and familiar sounds. Kubiatko and Prokop (2007) also quote earlier works by Trowbridge and Mintzes (1988), Kellert (1985) and Braund (1991) that pupils of all ages classify crawfish as a vertebrate or think that penguin is a mammal, and classify turtles and reptiles as amphibians or invertebrates. Kubiatko and Prokop (2007) report Slovakian elementary school students' serious problems with several common mammals as they see the habitat of animals as a more important criterion than taxonomy. Culturally transferred myths, and semantic similarity between some mammals and fishes are the other sources of difficulties Slovakian students experience in classifying animals. Similarly, Türkmen, Çardak and Dikmenli (2005) highlight linguistic factors as the reasons of Turkish students' misconceptions related to the meaning of systematic units. They report Turkish students' difficulty in classifying human beings, bacteria, protozoa, fungi, bats, dolphins and penguins.

As seen from the above mentioned examples, research on systematics and taxonomy mainly report significant findings for student groups. Bebbington (2005) reported that secondary biology teachers have also been unable to identify more than three species of common British wild flowers. Bebbington (2005) noticed that teachers at primary and secondary school level are not well trained to deal with taxonomic issues. Kubiatko and Prokop (2007) also point to teachers' lack of interest in taxonomy as the sources of students' misconceptions.

As greater stress is placed on ecological studies and the understanding of biodiversity, knowledge of species and taxonomic categories is becoming increasingly important. Yet, as stated by Kattmann (2001), this will fail to have any effect if the preconceptions of not only students but also of their teachers continue to be neglected. Both teachers and students should be able to identify at least a reasonable proportion of the more common species that surround them. They could be able to name an organism, recognise the major distinguishing features and place its ecological context (Katmann, 2001). When they perceive environment in its entirety, they become more prone to care about and conserve it (Papworth, Coad, Rist & Miller-Gulland, 2009).

METHODOLOGY

Sample of this study consists of 54 preservice elementary-science teachers enrolled in a compulsory General Biology course in a Turkish university. General Biology is a 6 hours a week-course, allocating 2 hours laboratory work. Content covers the Cell, Cell Division, and Classification of Life's Diversity in the autumn semester. Classification of Life's Diversity is a 12 hours subject of the course. Preservice teachers had previously studied biology in the secondary school, and General Biology is their first biology-related course in the science teacher education programme. Preservice teachers are expected to state, define and give examples of the components of taxonomy: description, identification, nomenclature, and classification at the end of the course (Simpson, 2006).

a) Data Collection

The study was conducted in three steps:

First step: Names of 100 species e.g. representatives of traditional phyla and kingdoms, and A3 size papers were handed to groups of three at the beginning of the subject "Classification of Life's Diversity". Names of the specimens were taken from the formal elementary and secondary school curricula. Photographs and/or line drawings were not used as they might hint the classification tasks. Preservice teachers were not provided with any verbal cues either. The underlying assumption was the preservice teachers' previous exposure to the names of these specimens for several times when they were learning about 'systematics and principles of taxonomy' in the elementary and secondary schools as intended by the formal curricula. Thus preservice teachers had already constructed mental models about the specimens and in order to elicit these models the word representations were solely used.

Preservice teachers were asked to classify the given species in subsequent three class hours. They worked in groups as the group work reinforced their ability to share diverse perspectives. They challenged each others' assumptions and exchanged their previous knowledge in forming the rationale of their task as the subject matter is not presented yet. It was intended to activate preservice teachers' prior knowledge through this collaborative activity (Kinchin, 2011). It is assumed that when a larger number of examples, including those of several habitats, is taken into account, preservice teachers would follow a general approach, and construct or use their own mental models (Kattmann, 2001).

Second step: "Classification of Life's Diversity", the characteristics and representatives of traditional kingdoms including the given species, were taught in 12 class hours including laboratory work and class activities such as observation of plant and animal cells under the microscope, preparation and observation of protozoa culture, fish dissection, categorization of samples brought i.e. fungi, plants and animals, etc. Throughout the classes, preservice teachers were expected to participate in discussions. As their works were handed back, they were asked to identify and mark the mistakes with red pens on the classifications they made. Then, the reasons for their mistakes were discussed within and between groups and with the researcher. This way, conditions for conceptual change were created i.e. preservice teachers were involved in useful arguments, and the learning situation brought up their misconceptions and created discrepancies between their old convictions and scientific view (Posner, Strike, Hewson & Gertzog, 1982). They were provided with opportunity to reconstruct their existing conceptions of classification (Wasmann-Frahm, 2009).

Third step: At the end of 12 class hours, preservice teachers were assigned to write individual reflection papers. They were required to discuss the reasons of their mistakes and address the sources of their inadequate knowledge. This way, in-depth results were sought (See Table 1 for the schedule of data collection).

Table 1. *Schedule of Data Collection*

3 class hours classification activity: group work and discussion	
4 class hours: Classification of Life's Diversity I: Monerans, Protists and Fungi Activity: Categorization of samples brougt Discussion and correction of mistakes made	2 class hours: Laboratory work (preperation and observation of protozoa culture)
4 class hours: Classification of Life's Diversity II: Plants and Animals Discussion and correction of mistakes made	2 class hours: Laboratory work (observation of animal and plant cells under the microscope, fish dissection)
Assignment: Individual reflection papers	

b) Data Analysis

Data were analyzed in two steps. First, the classifications made on A3 papers were evaluated. Pre-service teachers' classification criteria were identified. Mistakes were listed, grouped and categorized. Then, the reflection papers of the teachers were subjected to content analysis. Raw data were coded and thematized. Similarities and differences in responses were identified and grouped. Pattern of responses were drawn, inferences and generalizations were made (Miles & Huberman, 1994; Patton, 1990) about preservice teachers' reasoning of classification, misconceptions and sources of inadequate knowledge.

FINDINGS

The work of eighteen groups was evaluated. It was seen that all groups used the Linnaean classification during the group works. They categorized living things under four main groups i.e. Protists, Fungi, Plant and Animal Kingdoms. Although examples were not provided, 7 groups included Monerans in their classification, too. Main groups of classifications made were at the class level i.e. vascular and nonvascular plants for plant kingdom, and invertebrates and vertebrates for animal kingdom.Five groups used Invertebrate Chordates as a separate phylum in the Animal Kingdom. Eleven groups classified vascular plants as angiosperms and gymnosperms. There were groups which classified Plant Kingdom as 'spore-producing vascular seed plants-vascular seed plants and non-vascular plants', 'land plants and water plants (2 groups)', and 'green algae and land plants'. For Vertebrates, fish, reptiles, birds, amphibians and mammals were mentioned as subcategories by all except three groups which classified invertebrate chordates as vertebrates as well. Only one group classified mammals as egg-laying, pouched and placental mammals. For invertebrates; sponges, cnidarians, arthropods, annelids, molluscs and echinoderms were mentioned as the subcategories by 10 groups. Echinoderms were not included in 2 groups' classification and molluscs were not included in one group's classification. Two groups included crustaceans as a separate class and a group categorized insects as a separate phylum under invertebrates. There was also a group which classified invertebrates as land and water invertebrates. For protists, subcategories were slime molds, algae and protozoans in 5 groups. 4 groups also classified protozoans as ciliates, flagellates, amoeboids, and sporozoans.

When the classification of the given examples were examined, it was seen that preservice teachers had difficulty in classifying vertebrates, invertebrates and invertebrate chordates, angiosperms and gymnosperms, and protists. As seen in Table 2, they wrongly classified three mammals as fish i.e. seal, whale and walruse, and as an echinoderm i.e. walruse. Similarly, they classified four reptiles as invertebrate, amphibian and mammal i.e. snake and lizard as invertebrates, turtle as an amphibian and dinosaur as a mammal (3 groups). Preservice teachers also classified birds i.e. penguin, hen and duck, as mammal. 3 groups classified shark as a mammal. 4 groups classified salamander as a mammal, and 4 groups classified it as a reptile.

Table 2. *Preservice teachers' mistakes in classifying vertebrates*

	Wrong	Correct
Seal	Fish (3 groups)	Mammal
Walruse	Fish Echinoderm	Mammal
Whale	Fish	Mammal
Turtle	Amphibian	Reptile
Dinasour	Mammal (3 groups)	Reptile
Snake	Invertebrate	Reptile
Lizard	Invertebrate	Reptile
Penguin	Mammal (2 groups)	Bird
Hen	Mammal	Bird
Duck	Mammal	Bird
Salamander	Reptile (4 groups) Mammal (4 groups)	Amphibian
Shark	Mammal (3 groups)	Fish

As seen in Table 3, preservice teachers also made mistakes in classifying invertebrates. 5 groups classified squid as a fish. Sea anemone was classified as a gymnosperm. Sea cucumber, sea star and sea urchin were classified as molluscs. Coral and jellyfish were classified as echinoderms. Crab and lobster were classified as molluscs. Silkworm and butterfly were classified as bird. Flukes and earthworm were classified as reptiles.

Table 3. *Preservice teachers' mistakes in classifying invertebrates*

	Wrong	Correct
Squid	Fish (5 groups)	Mollusk
Sea anemone	Gymnosperm	Cnidarians
See cucumber	Mollusk	Echinoderm
Sea star	Mollusk	Echinoderm
Sea urchin	Mollusk	Echinoderm
Coral	Echinoderm	Cnidarians
Jellyfish	Mollusk	Cnidarians
Crab	Echinoderm	Arthropod
Lobster	Mollusk	Arthropod
Silkworm	Bird	Insect
Butterfly	Bird	Insect
Flukes	Reptile	Flatworm
Earthworm	Reptile	Annelida

Preservice teachers also made mistakes in classifying protists. For instance, 3 groups classified slime molds as fungi and a group classified it as a moneran. As seen in Table 4, Amoeba and plasmodium were classified as monerans. There was also a group which classified mushroom as a protist.

Table 4. *Preservice teachers' mistakes in classifying protists and fungi*

	Wrong	Correct
Slime mold	Fungi (3 groups) Monera	Protist
Amoeba	Monera	Protist
Plasmodium	Monera	Protist
Mushroom	Protist	Fungi

Preservice teachers also had difficulty in classifying plants. As seen in Table 5, they classified dicotyledon angiosperms i.e. strawberry, bean, chickpea, pear and apple as monocotyledons, and monocotyledon angiosperms i.e. garlic and onion as dicotyledons. There were groups which classified moss as an angiosperm and a dicotyledon. Similarly, ferns were classified as an angiosperm, a dicotyledon and as a nonvascular plant (2 groups). There were also 3 groups which classified horsetails as a nonvascular plant. One of the groups classified horsetails as an animal.

Table 5. *Preservice teachers' mistakes in classifying plants*

	Wrong	Correct
Strawberry	Monocotyledon (3 groups)	Dicotyledon
Bean	Monocotyledon (2 groups)	Dicotyledon
Chickpea	Monocotyledon (2 groups)	Dicotyledon
Pear	Monocotyledon	Dicotyledon
Apple	Monocotyledon	Dicotyledon
Banana	Dicotyledon (3 groups)	Monocotyledon
Garlic	Dicotyledon/Gymnosperm	Monocotyledon/Angiosperm
Onion	Dicotyledon/Gymnosperm	Monocotyledon/Angiosperm
Moss	Angiosperm/Dicotyledon	Nonvascular plant
Ferns	Angiosperm/Dicotyledon Nonvascular plant (2 groups)	Seedless vascular plant
Horsetail	Nonvascular plant (3 groups) Animal	Seedless vascular plant

There were examples that the preservice teachers had never heard of and/or had no idea about their characteristics. Some of these examples are tunicates (10 groups), amphioxus (10 groups), diatoms (5 groups), walruse (5 groups), lichens (5 groups), wheat (3 groups), taenia (3 groups), moss (2 groups), cedar (2 groups), horsetails (2 groups), dinosaur (2 groups), sea cucumber (2 groups), salamander (2 groups), platypus, abies, garlic, onion, banana, bean, chickpea, tulip, grasshopper, housefly, jellyfish, coral, snail, fluke, planaria, butterfly, silkworm, seastar, sea urchin, carp, crab, penguin, kangaroo, horse, and lizard (1 group).

Although majority of the groups could not classify tunicate, 2 groups classified it as a fish. One group classified it as an insect, one group classified it as a protist and one group classified it as a hydra. Classification of lichens was also problematic for the preservice teachers. 3 groups classified lichens as fungi, 2 groups classified as a protist and 2 groups classified as algae.

Reflections on the Mistakes Made

Preservice teachers listed the followings as the reasons of their mistakes in classifying the given examples: lack of interest and curiosity towards environment (n=7), not watching scientific documentaries (n=7), not observing living things in the environment (n=4), not following scientific journals (n=4), living in cities (n=3), not attending field trips (n=2), and fear of animals (n=2). They mentioned that "they memorized information about systematics and did not really learn" in the secondary school (n=3). They used their senses and external features of the examples as their main criteria of classification (n=2). One of the preservice teachers also pointed to the semantic similarity as his/her reason of mistakes.

Preservice teachers made the following explanations for the particular mistakes they made:

'Earthworm crawls. Therefore I classified it as a reptile.'
'Sharks are big as whales. Whales are mammals. Therefore I classified shark as a mammal (n=3)'
'Dinosaurs have big bodies. Mammals also have big bodies. Therefore I thought dinosaurs were mammals too.'
'Dinosaurs had had feet and they did not crawl. In cartoons, they walk, run, even fly. I thought they were mammals'
'Dinosaurs were huge. Big animals are mammals. Therefore, I classified dinosaur as a mammal.'
'Penguins do not fly. Their feathers are not similar to birds'
'I thought penguins give birth to their offspring'
'Penguins are similar to seals. Seals are mammals. Therefore, I classified them as mammals'
'Salamenders are similar to lizards. Therefore, I classified them as reptiles' (n=2)
Jellyfish is soft. Therefore, I classified it as a mollusc.'
'Seastar has a soft body. Therefore, I classified it as a mollusc'. (n=2)
'Crabs and lobsters' legs misdirected me.'

Reflections on the Activity

15 preservice teachers stated that they were both mentally and physically active during the activity i.e. they were grouping and regrouping the given examples in a group. They both enjoyed and learned. Working in groups and visualizing their mental images of classification helped preservice teachers (n=10) to realize their misconceptions, and contributed to their new learning. One of the preservice teachers stated that '*This activity helped me to correct my mistakes. It was more efficient then trying to memorize them from the text*'.

Although they studied classification of life's diversity starting from the early grades, there were also preservice teachers (n=3) who mentioned that they newly learned the classification criteria. One of the preservice teachers mentioned that '*Too many terms and concepts make learning systematics and taxonomy difficult. Till this time, we were not involved in such a student-centred activity. We were motivated to learn, search and discus during this activitys. I think it was highly effective for us*'. Similarly, 5 preservice teachers mentioned that the activity was very interesting. One of them stated that '*It was very thought provoking. After the class, I sought for all the examples we wrongly classified*'.

DISCUSSION

This study intended to examine the participant preservice teachers' conceptions of systematics and taxonomy through an instructional activity in which they were expected to categorise the representative examples into taxonomic groups. As stated by Vosniadou and Brewer (1992), determining preservice teachers' conceptions this way contributed more to their conceptual development and conceptual change considering their previous learning difficulties of systematics and taxonomy.

The classification criteria used by the groups showed that preservice teachers had basic knowledge about the Linneaen Taxonomy. They were knowledgeable about five kingdoms and different phyla as the "five kingdom" model that is commonly used in the Turkish elementary and secondary school science curricula. However, classifications they made highlighted their tendency to utilize intuitive folk taxonomy and/or analogue comparison. It is also inferred that they had difficulty in remembering what they learned and/or memorized about classification of animal and plant kingdoms.

Paralleling the findings of previous research (Kattmann, 2001; Kubiatko & Prokop, 2007; Yen, Yao & Mintzes, 2007; Wasmann-Frahm, 2009), preservice teachers' mistakes revealed the fact that they used habitat, locomotion and common features i.e. body size, external features, etc. as their main criteria of classification. For instance, sea mammals were classified as fish because they live in sea as fish do. Snake and lizard were classified as invertebrates because they look similar to earthworms and move like them. Hence earthworms were classified as reptiles as they crawl. Shark was classified as a mammal because it is big as whales. Dinosaur was classified as a mammal because of its body size and feet. Penguins were classified as mammal because they do not fly. Salamander was classified as a reptile as it moves like reptiles. Silkworm i.e. larvae of a moth and butterfly were classified as bird because they fly.

Semantic similarity was another reason of preservice teachers' mistakes of classification as identified in Yen, Yao and Mintzes (2007), Kubiatko and Prokop (2007) and Türkmen, Çardak and Dikmenli (2005)'s studies. However, it should be kept in mind that the preservice teachers were not provided with verbal cues, photographs and/or line drawings of the examples similar to the previous studies mentioned. The task demanded them to first use the linguistic clues, interpret them and then to match them with their existing cognitive structures. In the mean time, linguistic interpretations of some examples' names misled the preservice teachers as such the Turkish name of squid. Direct translation of squid's Turkish name is 'ink fish' that the preservice teachers classified it as a fish. Similarly, horsetails were classified as animals (as its name reminds horse) by the preservice teachers because of their Turkish names. Slime molds were classified as fungi. Although direct translation of slimemolds' Turkish name is 'soft mushroom', it is also considered that slime molds were previously classified in the Fungi Kingdom, and some sources still use this wrong classification.

Although there were examples that the preservice teachers had never heard and/or had no idea about their characteristics such as tunicates, amphioxus, diatoms, etc., it is critical to note that preservice teachers were not knowledgeable about the examples they see in their daily lives either. For instance, they classified hen, duck, strawberry, bean, chickpea, pear, apple, garlic and onion wrong. They listed grasshopper, housefly and banana among the examples that they do not know their characteristics. Preservice teachers mentioned that they made some of the classifications by heart such as classification of tunicates as fish, as insect, hydra and protist. As mentioned by the preservice teachers living in cities and having no opportunity to observe/contact various plants and animals, not watching documentaries and following journals and not attending field trips also influenced their responses. However, preservice teachers' comments about the activity highlighted the fact that their mistakes were mainly originated from the way they learned systematics and taxonomy in the past i.e. memorization of loaded information in the elementary and secondary schools. It is inferred that they were not exposed to biodiversity. They also lacked the experience of using scientific knowledge to classify a set of given examples in the school. Therefore, they had difficulty in classifying the given examples. Thus, they tended to use analogue comparison and/or intuitive folk taxonomy. Actively working in groups was yet more stimulating and efficient than listening and trying to memorize the representative examples of each taxa as mentioned by one of the preservice teachers.

Findings of this study point to the fact that instead of overloading information, effective instructional approaches should be used to teach systematics and taxonomy. Preservice teachers' prior knowledge should be explored and their alternative ideas about classification should be identified. This way instructional strategies that help preservice teachers to overcome the difficulties in understanding and applying biological classification can be developed (Kattmann, 2001). It should be kept in mind that their knowledge of living things is not necessarily gained from formal education which may serve simply to amplify and extend existing knowledge (Tunnicliffe, 2011). Preservice teachers should be provided with opportunities to endow their curiosity as they are expected to reinstall their future students' understanding and appreciation of nature (Leather & Quicke, 2009). As seen in this study, collaborative group work and/or constructivist- based tasks in a sequence might improve pre-service teachers' understandings. Interactive computer programs and web links also provide additional opportunities for observations, or with alternatives for live samples, dissections, preserved species, and prepared slides. Instructional activities which require comparing and contrasting, applying and analyzing also contributes to the development of preservice teachers' critical thinking skills (De Fina, 2003).

Limitations of the Study

This study has some limitations due to the possible influence of the number and set of examples presented to the preservice teachers. Preservice teachers could use different criteria in their classifications if they were presented with a smaller number and sets of examples (Kattmann, 2001; Tunnicliffe & Reiss, 1999). It is also accepted that designation of status to a particular ranking is in a state of flux. Previously recognized phyletic patterns may already be outdated as taxonomists working from different perspectives analyze new types of genetic data to establish current facts, interpretations and classification schemes (Starr & Taggart, 2001).

The study was conducted in an introductory biology course. Although preservice teachers were asked to categorize the representative examples into taxonomic groups, they were not asked to categorize the examples on the basis of their derived ancesteral traits. The small sample size may also form a limitation in generalizing the results. The results can be interpreted as culturally biased since semantic similarities between some invertebrates, vertebrates and plants were identified as a reason of mistakes preservice teachers made. However, results of the study were in line with most of the international research on systematics and taxonomy.

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Patterns of Conceptual Change Process in Elementary School Students' Learning of Science

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ABSTRACT

Conceptual change requires that an individual confronts and evaluates competing concepts based on their intelligibility, plausibility and fruitfulness. The purpose of this study was to gain thorough information of conceptual change process that occurred on the elementary school students in learning science, with the focus question: How does conceptual change take place in them? Subjects of study were second, third, and fourth grade students at one of the outstanding private Elementary schools at Serang district, Banten-Indonesia. The data were collected from observations and interviews of the participants. Analysis of data resulted in the patterns of conceptual change process in learning of science occurred on these student participants. Result from the qualitative analysis data revealed four patterns of conceptual change process in student's learning of science, i.e. addition, rearrangement, replacement, and extinction. Furthermore, conceptual change process of the elementary school students in learning science may involve any of these patterns and other mechanisms. Among those patterns, rearrangement seems to be the most inclusive, while extinction is the most limited to the science learning of elementary school students. The implication of these findings is that elementary school teachers need to be aware of the importance of students' basic knowledge and to develop teaching strategies that promote effective conceptual changing process in students learning of science.

Keywords: Elementary School Students; Private Elementary School Students' Learning Of Science; Conceptual Change Process; Addition; Rearrangement; Replacement; Extinction.

INTRODUCTION

Scientific understanding is necessary for scientifically literate society. A scientifically literate society can be achieved once the students learn science by engaging in learning activities that are interesting and meaningful to them. To support students' learning, teacher must be empowered to make instructional decisions about how students learn, and how resources are allocated during instruction. Therefore, students and teachers must be partners who work together to achieve both of these learning goals.

concepts in science is frequently linked to conceptual change learning. Conceptual change in students' learning is defined as the occurrence of change in either the status of a conception or a component of the conceptual ecology (Hewson & Thorley, 1989). Student learning, according to conceptual change model, occurs when a student actively constructing and transforming their own meanings, rather than passively acquiring and accumulating

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knowledge transmitted to them (Hewson, Beeth & Thorley, 1998; Posner, Strike, Hewson & Gertzog, 1982).

Thus, student learning is not an accumulation of bits of information, but it is an interactive and connective process that is required to changes, such as addition, linkage, rearrangement, and exchange of concepts (Barlia, 2004; Beeth, 1998; Hewson, Beeth & Thorley, 1998). The process of conceptual change in students' learning of science is very crucial to understand and need more elaboration answers. The rich information of the conceptual change process in students' learning of science will be worth for teacher to develop better teaching and learning process. For that reason, this study aims to seek the patterns of the conceptual change process occur in a science class at an elementary school.

The conceptual change model in learning science describes students' learning as a complex process analogous to the way in which conceptual change is believed to occur within the scientific community (Hewson & Hewson, 1984; Posner, et al., 1982; Strike & Posner, 1985; 1992). The conceptual change model authors looked at an analogy between student's conceptual learning in the classroom and the process of conceptual change in the science community. The conceptual change model views student learning as a rational process analogous to the way in which many contemporary interpretations in history and philosophy of science picture change in the knowledge of scientific communities. Thus, scientific knowledge is constructed based on a learner current understanding of phenomenon and the impacts of new information or new ways of thinking about existing information that bear on a concept.

A concept that serves as a focus for conceptual change efforts is one with the statue of a central and organizing factor (Posner, et al., 1982). Conceptual change can have several meanings which vary depending on who are discussing the topic. However, there are some underlying themes that seem to be agreed upon in the literatures. It is mainly in the details that definitions become less consensual change is a straightforward notion. Most authors of conceptual change model would agree that it can be mean to modify, to substitute something for another, to move from one form to another, to transform, or become different. However, when the phrase "*conceptual change is used, a new dimension is added*" (Hewson, 1988, p.323). Hewson, Beeth and Thorley (1998) argued that conceptual change involves the interaction between the new knowledge and the existing knowledge in order for the new knowledge to be reconciled with the old ones. White (1993, p.4) and Chi (2008) describe conceptual change as a substantial revision of belief. For this study, conceptual change is defined as the interaction of new ideas and an individual's existing ideas followed by an evaluation of the relative power, namely intelligibility, plausibility, and fruitfulness, of the two ideas with some mental actions on the ideas.

The model of conceptual change has two components, the conditional status of a conception and the conceptual ecology. The status of a conception can be defined as intelligible, plausible, or fruitful. Each status of the terms is attached to one or more components of the conceptual ecology (Thorley, 1990). The status conception based on Hewson (1981) is the degree to which the student knows, accepts, and finds the useful idea. The conceptual ecology associates to all of the students' knowledge and recognized. Strike and Posner (1985) proposed seven components of the conceptual ecology: anomalies, analogies and metaphor, prototypical exemplars and images, metaphysical beliefs and concepts, past experience, epistemological commitments, and other knowledge.

All components of conceptual ecology may contribute to determine the status of conception. Beeth (1998) and Hewson, et al., (1998) indicated that conceptual ecology focuses attention on the interactions within this knowledge base, and identifies the roles of the interaction between these knowledge either to support some ideas and raise their status or discourage others and reduce their status. Although the components of conceptual ecology are considered important in learning and knowledge development, student frequently do not identify components such as epistemological component or metaphysical beliefs when speaking. However, these components have been inferred from classroom discourse (Ohlsson, 2009). Other components such as analogies, metaphors, exemplars, and images are easier to recognize in literal student conversations (Chinn & Samarapungavan, 2009; Strike & Posner, 1985). All components of the conceptual ecology may contribute to determining the status of conception. If the individual experiences dissatisfaction with either the status of a conception or one of the ecological components underlying that conception, one of these four possible outcomes is likely to occur: (1) the new conception is rejected, (2) a new conception can be memorized, (3) a new conception can be captured by an existing conception, or (4) a new conception can be exchanged for a previous conception if reconciliation is not possible (Hewson, 1981, p. 386). Likewise, there are several ways in which the outcomes of conceptual change process occur, such as addition, rearrangement, replacement, or extinction (Barlia, 2004).

METHODOLOGY

This study is a descriptive case study that attempts to understand the process of conceptual change in elementary school students' learning of science with a specific research question: How does the conceptual change process in the learning of science take place on them? The study was conducted for two months during the months of September and October 2014. There were six participants who were students of grade two, three and four of an outstanding private elementary school at Serang district, Banten-Indonesia participated in this study. The grade four teacher and a parent of a grade four student also participated in this study. The selection of participants for this study is primarily based on their unique experience and different cultural background as well as their participation willingness and communication acceptances.

The data collection procedures were observations and interviews with selected student participants. Observations of teaching strategies and student's behavioral engagement in learning science resulted in information about the teaching sequence and the strategies the teacher used in her lessons. The researcher took several roles during the lessons, such as helping the teacher to set up the layout of the classrooms, asking questions to students, taking part in some student activities, and completing the day's field notes. The interview was focused on students' interpretation of the science tasks, the process learning science, and validating initial findings resulted from observation. The interview was conducted individually at least once a week in an informal condition where students were not involved in any learning activities.

Data analysis procedures included two general steps that analysis based on the researcher's intuitive reasoning from a complete reading of the data and case studies development. These two steps of data analysis took more than one cycle to produce the final case study. The first step in analyzing the data was to familiarize the general features of student engagement in learning science based on the entire data set. The final step in the data analysis procedure was to develop the case studies. Development of the case studies was specified on the patterns of conceptual change process in students' learning of science.

DISCUSSIONS OF RESEARCH FINDINGS

Teaching and Learning Process

Analyzed data gained from observation and interviews shows that teaching and learning activities in grade two, three and four of elementary school were dominated by students' presentations, hands-on experiments, problem solving, and student/teacher demonstrations. In daily classroom activities, the teachers implemented a variety of teaching and learning approaches that promote students' conceptual understanding. The teachers frequently motivated students to think about what they already knew, why something happens, and how their ideas are related to their daily lives. Those teacher's strategies used in teaching science match to the Cimer's (2007) statement and Kucuk's (2005) finding that are relating students' existing ideas to the new concepts offered leads to teaching science effectively.

By using these strategies, the teachers expected students to physically and mentally engage in learning science for conceptual changing. One of the most crucial teaching strategies used by the teachers in that elementary school is that the teachers always facilitates classroom dialogue by giving students a chance to discuss the problems in two or more ways of communication systems. The following is the grade four teachers' view of implementing these teaching strategies is that "*students' of elementary school are social beings*". Further, the teacher explains that:

> *"Interacting with others is very crucial for students as they learn about social interrelationships, confront with different ways of seeing, different solutions to problems, and different answers to questions".*

Instruction in this class was meaningful to students as stated by a grade three student.

> "*My teacher does a very good job of taking things in science and explaining it in ways that we understand. She (the teacher) really knows how to relate to us and how to make science fun and interesting"*(Aldi).

One of grade four students explained that;

> *"Science has always been an interest of mine. I always get involved in science lesson seriously because I enjoy them and I enjoy her (the teacher) teaching style. Also she is able to discuss both what happens and why this happens and she makes you think about what you already know, and relates it to our daily life"*(Shanty).

From all of the statements above, it can be inferred that warm and supportive relationships with the teacher and ample opportunities to interact with peers are essential if the elementary school students are going to develop an understanding of science concepts offered. A good environment for students learning permits, encourages, and even necessitates interaction with others, from simple communicative interaction to the complex negotiation of conflicts.

Patterns of Conceptual Change Process

The aim of this study is to examine the meaning, reasonability, and utility of the conceptual change process based on all of the data gained from a series of observation and interview. The study results in four patterns of conceptual change process that might occur on student' learning in science namely addition, rearrangement, replacement, and extinction. Addition can be defined as a creation of new concepts held without a significant change in the status of pre-existing concepts in a conceptual framework; rearrangement, reorganization or structural change within a system of interrelated concepts; replacement, the exchange or substitution of one concept for another; and extinction, the loss or disappearance of a concept (Barlia, 2004; Beeth, 1998; Hewson et al., 1998). Examples and the intelligibility, plausibility, and fruitfulness of the conceptual change possibilities are discussed in the following section.

1. Addition

Addition is adding information to knowledge rather than trying to rearrange, replace, or delete previous concepts and it occurs from the scratch. An important consideration is to determine and acknowledge what the students bring to the classroom, so that a teacher can help them to add ideas to their own conceptual frameworks in a useful fashion. Ebenezer and Gaskell (1995) stated that conceptual change for teachers and students is not just viewed as a replacement of old concepts, but also a process of learning to relate new ideas to appropriate contexts. The Ebenezer and Gaskell's (1995) study was focused on students' understanding of solubility and solutions. The students were asked to talk about and explain their views before starting the series of lessons. These talks included six distinct categories involved in the topic. After the lessons, there were two additional categories added to the student's existing knowledge. If the teacher had planned to influence learners to replace some knowledge or make it extinct, if that were even possible, it would have required a great deal of time. The following stories told by students' learning in science observed were very interesting to analyze as part of addition process in conceptual change learning in science:

In the second grade classroom, a disk was sat on a table. Dea, who is eight years old, sat down on the table and rocked the disk side to side, her eyes followed the movement of the marbles. After a few minutes, she carefully tipped the disk and rolled all the marbles towards her. She then experimented by tipping the disk to make the marbles move directly away from her. Next, Dea slowly tipped the disk, causing the marbles to roll in a circular motion around the disk. She stopped every now and then to reverse the direction of the motion.

As envision of the third grade students of the elementary school selected for this study in which several students were constructing a house made of cardboard box. They were trying to attach fronds of palm leaves and are faced with many problems in doing this, in constructing an archway across the front, and in covering the roof portion. These students had an idea to make their own house after reading a book about *Anak Dalam* tribe in Sumatra. The reading of this book and the students' idea of building a house resulted in rich activities that are integrating cultural studies, math, science, and literacy in the context of rich cooperative group interaction. They had to measure and estimated the lengths, weight, balance, and the properties of inclination of the various materials they used to construct the house.

From the two stories of students' learning activities above, it can be inferred that old theories about making the marbles move and building house in their tribes are not necessarily discarded in favor of new ones for the simple reason that the old theories remain useful in interpreting certain situations (Carey, 2011; Ebenezer & Gaskell, 1995). It is reasonable to acknowledge that students may find their original conceptions effective for interpreting conceptual structures that are new to them and use the familiar concepts as a foundation for adding new ideas. Given that ideas are held in contexts, the process of change may not be one of replacements of an idea but rather the distinguishing between contexts (Linder, 1993). Thus, a student may add new information into an appropriate context or conceptual hierarchy and use it for deeper understanding of the particular content.

Teachers always struggle with learning processes by making choices about viable ways for each student to learn concepts and how to present the material in a concise manner. To infer addition as one of possibilities patterns for some conceptual change helps us to believe that students may add to their existing knowledge. A good example to explain the process of accommodating the addition of new concepts to a pre-existing conceptual framework is the way a carpenter build a new house or make an addition to a pre-existing house. A good carpenter does not tear down his previous day's work, but extends it to a new level of accomplishment. A learner needs not necessarily to abandon or radically rearrange specific notions, but may add to them as a carpenter builds or as one might add information to a file.

Addition might be one of the ways for conceptual change. Thinking about teaching in terms of addition should help a teacher consider students' prior knowledge and understanding (Barlia & Beeth, 1999; Barlia, 2014). The implication of this finding is that in the teaching learning process, the teachers' understanding and acceptance of students' thoughts are the crucial part in promoting effective students' learning. The teacher then has a starting point to help the students learn more effectively by introducing concepts and ideas for the students to use in building more complex conceptual structures.

2. Rearrangement

Rearrangement, restructuring, or reorganization is one of the changing processes that will be discussed in this section. This section includes some examples which illustrate the idea of conceptual change as restructuring and discusses some of the literature which either supports or questions of this pattern of conceptual changing.

The following is the statement from one of the participants' parent who has just come from studying abroad. He studied at one of the state universities in United Stated of America for several years. His family was brought along during his study. Right now his son is sitting on the fourth grade. He told an experience about possibility of conceptual change process on his son:

> *"I have a son, at that time he was not quite five years old, who looked out a window at a winter snow storm and exclaimed, "Look, it's raining snow!" My son acquired the concept and term of rain and raining during the rain and dry seasons which originally knows in our home country before. For him, the term precipitation is unlikely to be intelligible, and any form of precipitation appears to be considered a form of "rain". As he grows older, he has more sensory experiences involving weather and grows in different linguistic ability (American English). By next winter, he was looking out on a winter snow; he is likely to exclaim, "Look, it's snowing!"* (A fourth grade student's parent).

From the statement above, it can be inferred that it is an example of conceptual reorganization, rearrangement or restructuring, since the concepts of rain and raining are not replaced by the concepts of snow or snowing. The child may reorder his knowledge and understanding of weather phenomena and language to accommodate the distinction between raining and snowing.

To better understand of how students restructure conceptual frameworks using new knowledge, it is important to review some theories which suggest how the conceptual reorganization, rearrangement or restructuring occurs. One way that cognitive science examines learning process is by studying the novice-expert shift in adults and how individuals restructure knowledge when they accumulate new facts. Some authors believe that conceptual change is knowledge restructuring (Carey, 1987; Hewson, et al., 1998), according to their view all knowledge has some structures. In one point of view, restructuring refers to the idea that adults (experts) consider or hold various concepts and the relationships among concepts differently than elementary school students (novices) hold a similar, or less complex concepts. Moreover, these relations allow the experts to create new abstract concepts and schemata which may not be accessible to novices. Adults (experts) manipulate their knowledge in a way to help them to deal with the underlying structure of the problems, otherwise elementary school students (novices) apparently do not, since they approach cognitive problems directly and naively. Carey (1987) views restructuring primarily as implicating a basic level-subordinate level shift. What a novice takes as a basic or fundamental concept may often be considered a subordinate level concept to an expert. A logical implication is that as in novices apprehend new concept, they may arrange the connections and position or status of interrelated concepts (Clement & Zeitsman, 1989). It may be that restructuring at conceptual frameworks through increasing their complexity is the way a novice becomes an expert.

Earlier theories of cognitive development framed by Vygotsky, Piaget, and Bruner suggested a general shift in the organization of conceptual structure at specific point in a child's development. For example, Bruner and Piaget mentioned the shifts from concrete to abstract. They assumed that conceptual change as restructuring focuses on a shift from categories based on a large number of similar features or spontaneous concepts to categories based on one or two principal features or dimensions---scientific concepts (Bloom, 1992). In other words, as concepts are better understood the distinctions between related concepts may become more fines. It appears that novices are conceptual lumpers while experts are conceptual splitters.

According to Carey (1987), there are two different senses of restructuring. In the weaker sense of restructuring new relationships among concepts are found which change the solutions to old problems without changing the core concepts of a conceptual framework or conceptual ecology. This weak restructuring happens, for instance, as a player gains expertise in chess. Novices and experts share the core concepts of chess. The rules of movement, approximate value of pieces, the objectives of the game are held in common. Experts acquire more subtle and complex concepts dealing with position and strategy that novices lack and so perceive the game with more finesse and subtlety than novices.

In the stronger sense of conceptual change, the same changing process occurs but accompanied by a change in the personal core concepts of successive conceptual systems of an individual (Ohlsson, 2009). Restructuring in the strong sense implies that the novices neither represent conceptual relationships in the same way as experts, nor specific core concepts or schemata available which experts may have at their disposal. The idea that reorganization, rearrangement, or restructuring of a conceptual system can and does occur in many instances is comprehensible, plausible, and at least to this group, fruitful (Hewson & Hewson, 1984). As the concepts are encountered they must be accommodated, assimilated or rejected. Assimilation implies integrating concepts into existing conceptual system which might reasonably entail a change in relationships among concepts and thus rearrangement. Accommodation implies adjusting an existing conceptual system to a new concept, which also implies rearrangement of some kind. Even rejection of a concept might cause some change in the relationships among concepts which could be called reorganization, rearrangement, or restructuring.

3. Replacement

To establish the plausibility and utility is the essential idea of replacement or exchange as one of the process for conceptual changes. Is it reasonable to believe that a concept can be replaced by another in an individual's conceptual framework? If the answer is yes, it does not necessary exclude the existence or use of other means for conceptual change. Within the scientific community, the concept of spontaneous generation is no longer accepted. The geocentric model of solar system is also no longer accepted. Each of these ideas failed to meet the demands of credibility and usefulness. Each concept was replaced by another which was more plausible and fruitful. Each concept was replaced because it was not compatible with new evidence. They no longer fit in the conceptual networks of which they had been a part. They were replaced, first within the scientific community and then a larger community, by concepts that provide a more accurate or acceptable representation of natural processes from the available data.

The concept of "spontaneous generation" was replaced by the idea that all living cells come from other living cells and by extension, that living organisms reproduce similar living organisms. The geocentric model of solar system was replaced by the more elegant and practical heliocentric model. The examples illustrate replacement as conceptual change at a social or community level. However, conceptual change begins with individual people. Each individual develops and organizes a personal conceptual ecology or a body of interrelated concepts. Rational individuals seek coherence and economy of concepts. When a learner is confronted with a conflict between a familiar concept and a new concept of equal or greater explanatory power, he or she must assimilate or accommodate the new concept (Rusanen &

Poyhonen, 2012; Strike & Posner, 1985, 1992). The individual must evaluate the competing ideas and somehow reconcile them, reject the new concept, or replace the old concept with the new one.

The process of accommodation involves the individual's evaluation of the competing concepts in three areas: intelligibility that is the concept must make sense to the individual, plausibility that is the concept must be credible and reasonable for the individual, and fruitfulness that is the concept must have practical value for the individual. Once the concepts are irreconcilable with regard to one or more of these basic levels, conceptual exchange might occur (Beeth, 1998; Hewson, 1981; diSessa, 2008). This indicates that the individual can no longer make sense of a situation or event with the old concept. It is no longer seems to fit. When a concept is no longer fit an individual's conceptual ecology, it may be replaced by a competing concept which is more intelligible, plausible or fruitful.

For the last four weeks, Dani and Nita, the fourth grader students have been taking walks to the small grove of trees adjacent to the schoolyard. Each student has selected a tree to be "his" or "her" tree and they have familiarized themselves with the trees, using both words and pictures. Today the teacher brought a video camera. Each child had the opportunity to direct the teacher to different parts of the tree he or she wanted to videotape. Upon returning to the classroom, the teacher played the videotape and the students guessed which tree was theirs. Dani was sure that the first was "his". "*See*", he directed the students. *"Look at the bottom of the trunk, there is a scar line on my tree!"*. The teacher stopped the tape while they examined it more closely. Nita argued, "My *tree has a line too, and look, the leaves are missing from one branch. It must be my tree*". The students continued to examine the tape, sharing the attributes of their trees and deciding which tree "*belongs*" to whom.

In the second grade classroom, various "*reconstruction*" materials were placed on the shelf. In one area of the room, Suti sat down on the floor and reached for the toy car hinged, interlocking parts. She called to Bambang, "*hey, let's make transformers*". Both students immediately began putting pieces together. Suti put together various pieces, swiveled the hinged parts around, and said, "*My car is changing into helicopter*". Bambang looked closely at what she has put together, looked at his "*Airplane*", and took it apart carefully, "*I'm making a 'copter transformer too*", he announced and started to duplicate Suti's construction.

From those two descriptions of students' learning activities it can be inferred that the idea of exchanging or replacing one concept with another which has greater power is both reasonable and intuitively attractive. As the students have new experiences, they frequently find themselves confronting discrepancies and errors in their understanding of many objects and phenomena. If the discrepancy or error is great enough, old ideas or concepts may be set aside and replaced by new concepts deemed by the individual to be more intelligible, plausible, and fruitful. The implication of all described above is that elementary school teachers have to be aware of students' conceptual condition if they want to be successful in facilitating students learning process for conceptual changing.

4. Extinction

The term 'extinction' was not found in the conceptual change literatures. However, borrowing from psychology, extinction refers to the tendency of a response to disappear if it is not reinforced (Engler, 1979; Rusanen & Poyhonen, 2012). Pavlov's classical conditioning experiments showed the necessity to provide reinforcement to elicit a particular response. Failure to provide reinforcement leads to the disappearance or 'extinction' of a learned behavior. To use the term extinction within the framework of conceptual change, one assumption is that a new concept must be or may be reinforced over time before a student could find it intelligible, plausible, and fruitful. Although possible, intelligibility, plausibility, and fruitfulness would not necessarily occur simultaneously and requires time for a student to grasp a new concept (Hewson & Hewson, 1984; White, 1993), thus internalizing it as part of their conceptual ecology is an important stage of students' learning. If the student fails to find the new concept intelligible, plausible, or fruitful, and does not utilize it and thus does not reinforce it, then it would be discarded or become extinct and is no longer a part of the conceptual framework.

In order to strengthening the idea of extinction as one of the possibilities in the conceptual change process of students' learning in science, a fourth grade teacher in this study asked her students about their opinion and conception of the rainbow. One of the fourth grade students (Sisca) explained her experience and conception about rainbow:

> *"When I was a little girl a get the story about a rainbow, the myth said that when rainbow come in the sky, there are seven angels taking bath in the pond, lake, or in the river dam. In that time, each time I saw a rainbow I was so curious to find the bathing angels in the ponds, lakes or in the river dams. But, up to now I never find it, and I never proof it. Last week my teacher demonstrated the formation of a rainbow. I realized that rainbow is the separation process of sunlight by the rain. So, right now, I will not believe that the rainbow is because the angels are taking bath in the river dams, ponds, or lakes".*

The statement can be inferred that the student's old conception about rainbow was replaced or might be punished even only for a while. The student conception about the occurrence of rainbow because of seven angels taking bath in the ponds, lakes, or river dams was replaced by the new conception. Student's believed that the occurrence of rainbow because of separating process of sunlight by the water poured or rain. Thus, the indication that replacement because of the prior knowledge was punished in the conceptual change process of students' learning science is crucial to be considered.

If a new concept replaces an antiquated concept or is accommodated as part of a new conceptual ecology, then the old concept due to lack of reinforcement becomes extinct. However, Bloom (1992) suggests that this is not a case. He states that one cultural context or intentional world is not replaced by another allegiance can change, but the previous context or conception does not disappear. Driver (1987) said that learning is an adaptive process in which conceptual schemes are progressively reconstructed. Carey (1987) stated that cognitive development consists, in part and in the emergence, of new theories out of these older ones, with the concomitant restructuring of important concepts and emergence of new explanatory notions. A new concept may become extinct if it is understood but not incorporated into an individual's conceptual ecology or framework. Therefore, extinction of an old concept would be less likely according to Bloom, Driver, and Carey.

To become extinct, a concept must lose its intelligibility, plausibility, or fruitfulness. In most cases of concept rejection or extinction, there is a concept available to replace the old concept, but sometimes there is no viable alternative, only an acknowledgment that the concept is no longer worth holding. Pintrich, Marx, and Boyle (1993) equate conceptual change to historical changes in scientific theories. They maintain that a theory is only replaced by a better theory and is not discarded unless the contradictory evidence is explained by this new and better theory. The better theory may be accepted without a confrontation of the old knowledge. One author has personally observed where students had a concept that was incorrect. In this science class, two-thirds of the students had the wrong idea about a control step that was part of specific procedure. The teacher decided to have students design an experiment that showed what would happen if the procedure was not followed.

After the experiment, students had to let go of their preconceived assumptions in the face of observing unexpected or a new data. In this example, the students had an alternative concept available to replace their original concept that evidence showed to lack fruitfulness and plausibility. In this instance had an alternate explanation not been available, the students might not have relinquished their original erroneous conception. Extinction does not seem to play a significant role in conceptual change. Behaviors may become extinct but concepts seem more likely to be modified or replaced rather than rejected outright or left to wither. Concepts achieve status in a conceptual ecology or framework because of their fruitfulness, intelligibility, and plausibility. Extinction implies not only a lack of these three traits, but a lack of an alternative concept with sufficient power to fill the niche left unoccupied by the extinct concept. Logically, conceptual extinction may only be a part of conceptual replacement or exchange and not an end in itself.

CONCLUSION

The conclusion drawn from this study is that each of the patterns for conceptual change namely addition, rearrangement/restructuring/reorganization, replacement or extinction, has some merit and explanatory power. It would be simplistic and reasonable to believe that conceptual change only happens one particular way. Since conceptual change occurs in the minds of individuals before being socially negotiated, there may be other means of conceptual change as well as the four described before.

Conceptual rearrangement or restructuring may subsume addition and replacement. It could also include conceptual extinction, if conceptual extinction does take place. For conceptual change to take place an individual must recognize that two or more analogous and competing concepts exist. If one concept is found to be more intelligible, plausible and fruitful than the other, then that concept is more likely to be retained and the less intelligible, plausible or fruitful concept abandoned. If a new concept is retained and a previously held concept abandoned the process may be considered replacement. If an existing concept is reconcilable with a new and analogous concept then the new concept may become part of a conceptual ecology through addition or rearrangement. Addition considered as a form of rearrangement in the sense that a new niche is created in a conceptual ecology when a new concept is added.

The pattern of changing, extinction is problematic where the extinction might be considered an aspect of replacement. There is abundant evidence that elementary school students, do not give up existing concepts easily. Even when a new concept appears to have replaced a previously held naïve or alternate conception the “old” concept often remains, although in a position of lower status in the conceptual ecology. Could this be analogous to the way that old clothes which no longer fit may be put away in storage for some indefinite period of time? The clothes are not used but can be accounted for and are held against future use. Might replaced concepts be held in a similar manner? If so, then conceptual replacement may also be visualized as a form of conceptual rearrangement. In summary, each of the conceptual change patterns, i.e., addition, restructuring, replacement, and extinction that might be occurred in elementary school students is feasible as means of conceptual change.

Restructuring or rearrangement is the most inclusive and fruitful of the four patterns offered above since it can include addition and replacement. Extinction is the weakest pattern since it seems less plausible than the other three. The implication of the findings is that the elementary school teachers’ knowledge of the patterns of the science concept changing process is required in designing elementary school students’ learning process of science effectively. Elementary school teachers need to be aware of the importance of students’ basic knowledge for the effective conceptual change process in teaching and learning science. In addition, teachers need to develop teaching strategies that promote better students learning in science for conceptual changing.

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