THE EFFECT OF INNOVATIVE INSTRUCTIONS ON PRE-SERVICE SCIENCE TEACHERS' CONCEPTION ABOUT THE NATURE OF SCIENCE: A SCIENTIFIC INVESTIGATION

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ABSTRACT

Learning science without having a correct conception of the nature of science is a flaw in science education that warrants concern, all the more if science teachers teaching science have misconceptions about the nature of science. This paper is based on an action research carried out during Nature of Science (NOS)(SCE500) course for 56 pre-service science teachers in a science education programme. The study focuses on the learning outcomes on aspects of NOS that have been reported as common misconceptions among science learners. It specifically looks into the results of three aspects that are related to scientific investigation, i.e. its role, its demands on imagination and its process. The results show that after attending innovative lessons for a semester, the misconceptions of the pre-service science teachers regarding three aspects of NOS: experiments in science confirm scientific ideas, scientists use their imagination at the early stage of investigation only, and hypothesis-experiment-conclusion is a scientific method used by all scientists have reduced significantly.The paper also highlights in brief the innovative and creative elements pertaining to a variety of approaches used in the set induction of every class session based on the consensus mode of the Nature of Science. The paper concludes with the feedback on the course by the pre-service teachers.

Keywords: *Nature of Science, Scientific Investigation, Pre-service Science Teachers, Innovative Instruction*

INTRODUCTION

Science literacy encompasses not only knowledge of science, but also about the nature of science (NOS) in accordanc to the definition of science education reform (Enger & Yager 1998; American Association, 1990). Nature of Science that illuminates how scientific knowledge has developed and the roles which scientists have played during such a process are deemed two fundamental aspects that are considered necessary and essential for students to know. However, research in NOS has revealed that the level of misconception about NOS among science students as well as science teachers including pre-service teachers is high and needs immediate attention (Buaraphan & Sung-Ong, 2009; Khishfe & Lederman, 2006; Akerson & Hanuscin, 2007; Ling et al., 2008; Tan & Boo, 2003; Jain, Beh & Nabilah, 2013; Beh, 2011). This gives rise to concerns on how to address the misconceptions. Lederman and Abd-EL-Khalick (1998) suggest the explicit approach in introducing NOS to students. However, there is a lack of studies on the effects of learning outcomes of innovative instruction in NOS which this paper aimed to address.

In the science teacher preparation programme in the selected institution, a public university, the course, SCE500-Nature of Science (NOS) is included as a science based core subject in the curriculum in line with the reform in science education. In line with the constructivist movement, the instructional design of the NOS course includes among others, a strategy addressing explicitly the common misconception of NOS among students. This paper is based on an action research carried out by the author who was also the instructor of SCE500. The action research consisted of three phases: 1. Entrance Survey: Identifying misconceptions, 2. Innovative Instruction: The use of set inductions together with the chapters authored by Kosso(1997), and 3. Exit Survey: The changes in misconceptions.

This paper looked into classroom experiences and highlighted in detail the conceptual change with regard to misconceptions of NOS in three areas related to scientific investigation: its role, its demands on imagination and its process at the entrance level among pre-service science teachers taking SCE 500 course.

INNOVATIVE INSTRUCTION: THE SCE500 EXPERIENCE

SCE500-The Nature of Science is a core subject taken by all undergraduates enrolling in the pre-service science teacher programme at the institution in which this research was conducted. The course content is philosophically biased and the approach is inclined to constructivist approach. This approach is deemed appropriate as it ensures not only meaningful learning but also positive learning outcomes such as creative and critical thinking, leadership, communication, presentation, problem solving and research skills. These skills are deemed essential besides content mastery for students who aspire to become effective teachers.

The course content is based on the textbook, Reading the Book of Nature by Kosso (1997) to guide the students through the philosophical perspectives of the major ideas in science, such as Theory and Law, Explanation and Truth, and Observation and Confirmation. Kosso provides a view of science that mimics the constructivist approach in which observation relies on theory to give it meaning. However, many students find it challenging to capture this view because of the philosophical dimension. Hence, before the class embarked on the discussion of the above stated topics, the students were given readings to obtain an overview of The Nature of Science. The objectives of the overview were to provide a general framework of the Nature of Science to enhance understanding of the philosophical arguments set in the textbook, and to complement the content in Kosso's book. A topic on Religion and Science was included at the end of the course. The main objective was to enable students to internalize what is not science.

To enhance students' interest and conception about the Nature of Science, activities similar to those suggested by Lederman and Abd-EL-Khalick (1998) were incorporated in the class.The activities were conducted at the beginning of each of the weekly three hour class discussion by the instructor. This was named as "Induction". Students found the inductions interesting, illustrative and illuminating. The following is an example, one of the many inductions which was created (Refer to Beh, 2011 for more examples of inductions).

AN EXAMPLE OF INDUCTION

In this induction, students were asked to draw the magnetic field around a bar magnet. Many had no problem coming up with a drawing similar to the one in the science textbook (Figure 1).

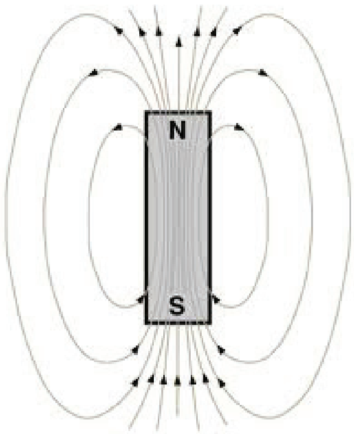

Figure 1

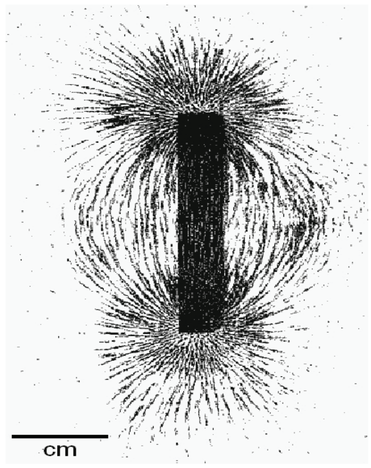

Figure 2

Then, a bar magnet was placed under a piece of transparency paper in the overhead projector. A student was asked to sprinkle iron filings over the magnet and then to gently tap the edge of the paper. The filings showed a pattern of magnetic field lines in the surrounding space as in Figure 2. Students were both intrigued and amazed with the visual image of the formation of the magnetic field pattern. Subsequently, the students were asked the following questions:

- Do you see Figure 1 in Figure 2? Where are N and S and the arrow signs in Figure 2?
- Do you see the lines of force in Figure 2?
- Do you think magnetic field has lines in its natural setting? If it does not, how do you get to see the pattern traced out by the filings?

In the class discussion relating to these phenomena of magnetic field pattern, the following ideas were introduced:

- The particular pattern is formed by the filings because each tiny iron filing has been induced into a temporary magnet. The iron filings with the magnetic property of "different poles attract and similar poles repel" align to form lines. The gaps between the lines are due to the repulsive force created between filings that are aligned side by side. The magnetic lines of force is a physic construct invented by scientists. This construct is just a representation of an invisible entity but useful in that it has predictive value.
- As for the labels N and S and the arrow signs which appear in Figure 1, these are conventions agreed by scientists in defining the direction of a magnetic field, i.e. the direction indicated by the needle of a compass when it is placed in the field.

The following features of nature of science were then introduced:

- Scientific constructs are generated to make the natural world comprehensible and intelligible.
- The constructs have predictive value. Based on these constructs, for example, the magnetic field pattern of two bar magnets placed side-by-side can be predicted.
- Scientific ideas are grounded in agreement among scientists.
- Since "magnetic lines of force" is a human construct, it can be subjected to change when a better representation is created in future.
- What constitutes observation is the effect of the unobservable scientific entity and not the scientific entity itself.

METHODOLOGY

An inventory (Refer to Appendix) was used to gauge students' conceptual change about the Nature of Science after they attended SCE500 course. The inventory was constructed based on the eight common misconceptions of the nature of science as indicated from previous research: Parker et al. (2008) on American students, Tan and Boo (2003) on Singaporean pre-service teachers, and its modification by Lin et al. (2006). Test-retest reliability on twenty pre-service science teachers showed a reliability index of 0.89. As for validity, content validity was carried out by a panel of three science instructors who had experience in teaching NOS.

The inventory comprising eight items was administered to 56 pre-service science teachers before (Entrance) they started and after (Exit) they took SCE500 course. The pre-service teachers were required to response to the Likert scale of 1-5 where 1 indicated Strongly Agree to 5 which indicated Strongly Disagree. However, this paper only looked into the responses of the pre-service science teachers for three items in the inventory, i.e. Items 1, 2 and 6 that were related to scientific investigation. The items were named as Statements 1, 2 and 3 as below:

Statement 1: Experiments in science confirm scientific ideas,
Statement 2: Scientists use their imagination only at the early stage of investigations, and
Statement 3: Hypothesis-experiment-conclusion is the scientific method used by all scientists.

Besides that, three pre-service teachers were interviewed to gauge their views for statements 1-3 before and after the course.

RESULTS AND DISCUSSION

Statement 1: Experiments in science confirms scientific ideas.

Table 1 shows the responses of the pre- service teachers for Statement 1 at the entrance and exit levels for SCE500 course.

Table 1: Pre- Service Teachers' Responses to Statement 1

Major		Entrance Mean	Exit mean	Gain
Mathematics	(n=22)	1.7	4.4	2.7
Physics	(n=16)	1.9	3.2	1.3
Biology	(n=18)	2.0	3.2	1.2
Overall	(n=56)	1.9	3.6	1.7

Scale: 1=Strongly Agree 2=Agree 3=Not Sure 4=Disagree 5=Strongly Disagree

Table 1 shows the average score of the pre-service teachers in accordance to their respective major before and after the course SCE500 in response to statement 1,"Experiments in science confirm scientific ideas**"**. Table 1 reveals that before the course, the majority of the pre-service teachers agreed with the statement. After years of studying science, the majority of the pre-service teachers had the misconception that scientific ideas can be confirmed through experiments despite under-determination in science, i.e. science can be disproven but cannot be proven according to Karl Popper's notion of falsification as the essential feature in the process of science (Kosso, 1997). In other words, experiments in science provide evidence for theories to be tested but the evidence obtained cannot be taken as confirmation and truth. However, after completing SCE500 course, the majority of them changed their views regarding the role of experiments. They now viewed that experimental data merely provides evidence for ideas to be tested. Table 1 shows an overall gain of 1.7 in scale with mathematics pre-service teachers leading with a gain of 2.7, followed by physics and biology pre-service teachers with gains of 1.3 and 1.2 respectively.

Table 2 shows three examples of explanations provided by three pre-service teachers (one from each major) who indicated a change in their view in response to Statement 1 (i.e. Agree/Strongly Agree before taking the course to Disagree/Strongly Disagree after taking the course). The explanations further substantiated the positive conceptual change from the misconception harbored before the course to the acquisition of the correct conception after the course by these pre-service science teachers. The correct conception is that experiments in science do not confirm scientific ideas; they only provide evidence for the ideas to be tested.

Table 2: Change of Views among Pre-service Teachers for Statement 1

	Change of views	
Major of pre-service teachers	**Before taking SCE500 course**	**After taking SCE500 course**
Biology	"For example, to prove that inertia exists, scientist carries out an experiment of spinning a "gasing" (top)."	"This is because there are no absolute "confirmation" in science as science never touches the truth."

Mathematics	"Yes, experiments in science must be related with scientific ideas to get the right conclusions."	"Experiment is to support the theory (idea), not to confirm/ prove."
Physics	"Because most of us believe in what we see. The same goes to experiments being done. The results obtained will prove the scientific ideas that we initiate."	"Experiments done are just to verify the ideas that scientists have."

A cross tabulation of individual responses to Statement 1 before (Q1) and after (PQ1) SCE500 course was carried out to reveal in detail the changes in pre-service teachers' responses to Statement 1. Table 3 shows the results.

Table 3: Cross Tabulation of Responses to Statement 1 before and after SCE500 Course

Major			PQ1				Total
			1.00	2.00	4.00	5.00	
Mathematics	Q1	1.00	0	1	0	8	9
		2.00	1	1	4	4	10
		3.00	0	0	0	3	3
	Total		1	2	4	15	22
Physics	Q1	1.00	0	1	1	3	5
		2.00	1	3	5	0	9
		3.00	0	1	0	0	1
		5.00	1	0	0	0	1
	Total		2	5	6	3	16
Biology	Q1	1.00	1	0	3	1	5
		2.00	0	6	3	0	9
		3.00	0	0	0	2	2
		4.00	1	0	1	0	2
	Total		2	6	7	3	18
Total	Q1	1.00	1	2	4	12	19
		2.00	2	10	12	4	28
		3.00	0	1	0	5	6
		4.00	1	0	1	0	2
		5.00	1	0	0	0	1
	Total		5	13	17	21	56

Scale: 1=Strongly Agree 2=Agree 3=Not Sure 4=Disagree 5=Strongly Disagree

Table 3 shows that the majority of the pre-service teachers (38/56; 67.9%) changed their responses from Strongly Agree and Agree (i.e. 1 and 2) to Disagree and Strongly Disagree (i.e. 4 and 5). Table 3 also reveals that the percentage of change for Mathematics major was the highest among the three groups with 86.4% (19/22), followed by Physics major (9/16;56.3%) and Biology major (10/18; 55.6%). It is also noted that a significant high percentage of students (16/56; 28.6 %) were positive with the statement before and after the course with a high percentage from Biology and Physics majors (i.e 7/18, 38.9% and 6/16, 37.5%) respectively. Mathematics majors had only 13.6% (or 3/22).

These students represented what research in the constructivist paradigm termed as the hard core in that they tenaciously held on to their misconception that the role of experiment was to confirm or prove scientific ideas. With the exception of Mathematics majors, it appears that Popper's idea using the mathematical logic of A=> B but B ≠>A; however, –B=> -A as part of the course content illustration appears to be too challenging for this group of pre-service teachers to internalize. This contradicted with what happened in the class, i.e. they appeared to understand when the following analogy, "Smart boys wear red shirts; but boys wearing red shirts are not necessarily the smart ones" was dealt with in the discussion with regard to a theory predicting a phenomena, but the phenomena that happens does not indicate that the theory is absolute right (i.e., proven or confirmed). The tenacity of the view that an experiment "confirms"an idea can be traced back to the rampant usage of the word "proven" in school science laboratory reports. Students had difficulty in differentiating the subtle meaning between phrases such as "seeking evidence to support scientific idea" with phrases that replace the word "support" with "verify/confirm/ or prove". Similarly, students had difficulty to fathom the subtle differences in meaning of other words or phrases such as "truth", "reflection of truth" and "indicator of truth". One has to admit that a good grasp of English is essential for a course such as NOS with its philosophical dimension. However, this demand on English language ability is an uphill challenge to many of the pre-service teachers. This is because many of them are rather weak in English as English is their second language. Table 3 further reveals that two pre-service teachers (3.6%) regressed from the scales of 4 and 5 (Disagree/ Strongly Disagree) to 1(Strongly Agree).

Statement 2: Scientists use their imagination only at the early stage of investigation.

Table 4 shows the responses of the pre-service science teachers for Statement 2 at the entrance and exit level for SCE 500 course.

Table 4: Pre-Service Teachers' Responses to Statement 2

Major		Entrance Mean	Exit mean	Gain
Mathematics	(n=22)	2.8	4.1	1.3
Physics	(n=16)	2.3	4.3	2.0
Biology	(n=18)	2.7	4.0	1.3
Overall	(n=56)	2.6	4.1	1.5

Scale: 1=Strongly Agree 2=Agree 3=Not Sure 4=Disagree 5=Strongly Disagree

Science is a blend of logic and imagination as thought and imagination are used in coming up with theories and creative insight is required to recognize the meaning of the unexpected in data analysis (AAAS, 1990). Hence, scientists use their imagination not only at the early stage of investigation but throughout the whole process of investigation. Table 4 shows the average score of the pre-service teachers in accordance to their respective major before and after the course, SCE 500 in response to Statement 2 "Scientists use their imagination only at the early stage of investigation". Table 4 reveals that the average scores were below 3 before the course. However, the average score was above 4 after the course. The results indicated that a vast majority of the pre-service teachers agreed with the statement before the course but after the course, their view changed to the correct conception that "Scientists use their imagination at all stages of investigation". Table 4 shows an overall gain of 1.5 in scale with Physics major leading with a gain of 2.0, followed by mathematics and biology majors with a gain of 1.3.

Table 5 shows three examples of explanations provided by three pre-service teachers (one from each major) who indicated a change in their view for Statement 2 (i.e., Agree/Strongly Agree before taking the course to Disagree/Strongly Disagree after taking the course). The explanations further substantiated the positive conceptual change from the misconception harbored before the course to the acquisition of the correct concept after the course by these pre-service science teachers. The correct concept is "Scientists use their imagination not only at the early stage of investigation but at all stages", such as during theory and hypothesis building, experimentation, and during data interpretation as ideas in science such as backholes, DNA, and chemical bonding are an abstract entity.

Table 5: Change of Views among Pre-service Teachers for Statement 2

	Change of views	
Major of pre-service students	**Before taking SCE 500 course**	**After taking SCE 500 course**
Biology	"Early imagination is needed to get ideas to investigate something. The end stage cannot use imagination but needs to be proven by a reason and proof".	"Use at the early stage to imagine and come out with a hypothesis; also use imagination at another stage to make people have "sense"(reason) and can imagine what they explain".
Mathematics	"Yes, because in the early stage of investigation, they only use their imagination before they do the experiments".	"Because the scientists always use their imagination when doing the investigation".
Physics	"I agree because scientists in the early stage lack devices for investigation, so they just use their critical thinking".	"Scientists use imagination at every stage of investigation".

A cross tabulation of individual responses for Statement 2 before (Q2) and after (PQ3) the pre-service teachers took the SCE 500 course was carried out to reveal in detail the changes in their responses towards Statement 2. Table 6 shows the result.

Table 6: Cross Tabulation of Responses to Statement 2 before and after SCE 500 Course

Major			PQ2			Total
			2.00	4.00	5.00	
Mathematics	Q2	1.00	0	2	1	3
		2.00	0	3	0	3
		3.00	2	5	6	13
		4.00	1	1	0	2
		5.00	0	0	1	1
	Total		3	11	8	22
Physics	Q2	1.00		1	3	4
		2.00		5	1	6
		3.00		3	1	4
		4.00		2	0	2
	Total			11	5	16
Biology	Q2	1.00	1	1	1	3
		2.00	0	6	1	7
		3.00	0	1	0	1
		4.00	1	4	2	7
	Total		2	12	4	18
Total	Q2	1.00	1	4	5	10
		2.00	0	14	2	16
		3.00	2	9	7	18
		4.00	2	7	2	11
		5.00	0	0	1	1
	Total		5	34	17	56

Scale: 1=Strongly Agree 2=Agree 3=Not Sure 4=Disagree 5=Strongly Disagree

Table 6 shows that the majority of the pre-service teachers (41/56; 73.2%) changed their responses from Strongly Agree, Agree, and Not Sure (i.e. 1, 2 and 3) to Disagree and Strongly Disagree (i.e., 4 and 5). Table 6 also reveals that the percentage of change for physics major was the highest among the three groups with 87.5% (14/16) followed by Mathematics (17/22;77.3%) and Biology major (10/18; 55.6%). Only a small percentage of the pre-service teachers (3/56; 5.4 %) were positive or not sure with the statement before and after the course. These three pre-service teachers were from Mathematics (2) and Biology (1). None was from Physics. These three represented what research in the constructivist paradigm termed as the hard core, i.e. that they tenaciously held on to their misconception pertaining to the role of imagination in the process of scientific investigation. It was revealed that a high percentage of the pre-service teachers indicated Not Sure (18/56; 32.1%), Strongly Agree or Agree (26/65; 46.4%) with Statement 2 before the course.

Those who stated Not Sure offered the following reasons: "Maybe depends on situations and condition","I am not sure, but I think it is no because the scientists need to imagine about the whole stage also to get the accurate result", and "I'm not sure about that, but for me when I was doing some experiments of science when I was in secondary school, I always used my imagination of what was going to happen after we conducted some experiments". It is interesting to note that in the third explanation, the pre-service teacher drew on her school science laboratory experience on the need for imagination.

Those who agreed with Statement 2 offered the following reasons: "Scientist(s) use their imagination at the early (stage) of investigation such as hypothesis", "Scientists use their imagination as the way to think before they start to investigate or study", "After the imagination, they will come up with the idea and prove it by experimenting or following other theory", and "Scientists always make hypothesis first before doing the investigation". From the explanations, it can be seen that to the pre-service teachers, ideas, hypothesis, and theory building involve imagination before carrying out an investigation.

Table 6 also reveals that before the course, 12 students (12/56; 21.4%) were not in favor of the statement and out of these students, 10 persistently disagreed. However, two apparently changed their view to "Agree". Investigation of these two students revealed that although these two students indicated "Agree" with the statement, "Scientists use their imagination only at the early stage of investigation", their explanations indicated otherwise. To illustrate, the students stated the following.

"Yes, because all the phenomena occur, will investigate by scientists. So scientists will use their imagination to explain the thing as long as it is logic" (Biology major)

"Yes, without imagination, how scientist could done an experiment" (Mathematics major).

The discussion of course content pertaining to the issues of underdermination and theory-laden observation may have led to the change in the pre-service teachers' conception, i.e. that imagination is needed not only in formulating theory/hypothesis but also in data interpretation in their observation report.

Statement 3: Hypothesis-experiment-conclusion is the scientific method used by all scientists.

Table 7 shows the responses of the pre-service science teachers for Statement 3 at the entrance and exit level for SCE 500 course.

Table 7: Pre-Service Teachers' Responses to Statement 3

Major	Entrance Mean	Exit Mean	Gain
Mathematics (n=22)	1.5	4.0	2.5
Physics (n=16)	1.8	2.4	0.6
Biology (n=18)	1.8	2.6	0.6
Overall (n=56)	1.7	3.1	1.4

Scale: 1=Strongly Agree 2=Agree 3=Not Sure 4=Disagree 5=Strongly Disagree

Although fundamentally, various scientific disciplines tend to rely on evidence, hypothesis, theory, logic, and imagination, there is no single universal step-by-step scientific method that all scientists follow. The mode of investigation is defined by the phenomena and the context it is being investigated. Hence, a variety of methods can be possibly used, such as historical, experimental, qualitative, and quantitative (AAAS, 1990). However, due to typical laboratory experiences that place great emphasis in writing laboratory reports in a particular form both at school and college levels, inevitably, students conceive that the scientific inquiry they experience is the only one. Hence, it is not surprising that Table 7 shows that the average score before SCE 500 course was low at 1.7 with Biology and Physics majors leading with a mean of 1.8, followed by Mathematics major with a mean of 1.5. However, after the course, improvement was very slight with an average gain of 1.4. The gain for mathematics major was high at 2.5, but the gains for Biology and Physics majors were minimal with 0.6 and 0.8 respectively. The vast difference may be that the mathematics majors were influenced by the project on misconception that they carried out pertaining to this notion.

Table 8 shows four examples of explanations provided by five pre-service teachers (two each from biology and chemistry majors and one from Physics major) who indicated a change in their view for Statement 3 (i.e., Agree/Strongly Agree before taking the course to Disagree/Strongly Disagree after taking the course). The explanations further substantiated the positive conceptual change from the misconceptions harbored before the course to the acquisition of the correct conceptions after the course by these pre-service science teachers, i.e. "Hypothesis-experiment-conclusion is the scientific method taught in school science; however, in reality, scientists from different disciplines may follow different methodology pathways depending on the area of study". For instance, geologists do on-site study and theoretical physicists make predictions based on their theoretical constructs. It is interesting to note that especially for the physics major, many who disagreed with Statement 3 after the course provided explanations that it was similar to the method used in schools (Table 8).

Table 8: Change of Views among Pre-service Teachers for Statement 3

	Change of Views	
Major of pre-service teachers	**Before taking SCE 500 course**	**After taking SCE 500 course**
Biology	"This scientific method is used by all scientists to explain something accurately and scientifically".	"It is not used by all scientists. Some might only observe the other experiment and make their explanation".
	"Many hypotheses are tested using this way as far as I am concerned".	Not necessary. Actually there in no scientific method. Scientific method that we always talk about is just a guideline. It is good to use this method though. For example, Issac Newton discovered gravity not through this scientific method".
Mathematics	"Because it is the most effective and systematic way when doing experiment".	"No, because there are other methods also used by scientists".
	"It can cover all data needed".	"There are many other ways can apply such as just to do observation to explain a phenomenon".
Physics	"I agree because hypothesis, experiment and conclusion are being used by scientists at the early stage".	"Hypothesis-experiment-conclusion is a scientific method used since we were in school till now".

A cross tabulation of individual responses to Statement 3 before (Q6) and after (PQ6) the course was carried out to reveal in detail the changes in the pre-service teachers' responses towards Statement 3. Table 9 shows the results.

Table 9: Cross Tabulation of Responses to Statement 3 before and after SCE500 Course

Major			PQ6					Total
			1.00	2.00	3.00	4.00	5.00	
Mathematics	Q6	1.00	1		2	4	5	12
		2.00	1		0	5	3	9
		3.00	0		0	0	1	1
	Total		2		2	9	9	22
Physics	Q6	1.00	2	4		1	0	7
		2.00	1	4		1	1	7
		3.00	0	0		0	1	1
		5.00	1	0		0	0	1
	Total		4	8		2	2	16
Biology	Q6	1.00	2	1		3		6
		2.00	1	7		1		9
		3.00	0	0		3		3
	Total		3	8		7		18
Total	Q6	1.00	5	5	2	8	5	25
		2.00	3	11	0	7	4	25
		3.00	0	0	0	3	2	5
		5.00	1	0	0	0	0	1
	Total		9	16	2	18	11	56

Scale: 1=Strongly Agree 2=Agree 3=Not Sure 4=Disagree 5=Strongly Disagree

Table 9 shows that only slightly more than half of the pre-service teachers (29/56; 51.8%) changed in their responses from Strongly Agree, Agree, and Not Sure (i.e. 1,2 and 3) to Disagree and Strongly Disagree (i.e. 4 and 5). Table 9 also reveals that the percentage of change for Mathematics major was the highest (18/22; 81.8%), followed by Biology (7/18, 38.9%) and Physics (4/16, 25.0%). The percentage of change for Mathematics major which far exceeded that of Biology and Physics majors may be the effect of the variation in the misconception project that the mathematics major had taken with an emphasis in this aspect of NOS. The majority of the Biology (11/18, 61.1) and Physics (11/16, 68.8%) majors retained their entrance misconception even after the course; or else, only about 9% of the mathematics major (2/22) did so. Below are examples of the explanations offered by this group of pre-service teachers.

Before SCE 500 course: “Hypothesis is just the first deduction of scientists. When the result is found, the conclusion is made”.

After SCE 500 course: “Before doing the experiment, scientists will normally construct the hypothesis, which is the early prediction based on the existing theory”.

It looks like the notion of the scientific method that the pre-service teachers experienced in science at school and at college was rather tenacious. This could be due to the fact that experience is more convincing than words.

CONCLUSION

The study reveals that before SCE 500 course, misconceptions pertaining to the three aspects of scientific investigation from the perspective of nature of science were high among the pre-service science teachers. However, after the course, most of the pre-service teachers’ misconceptions were reduced significantly. The pre-service teachers responded positively to the innovation in the classroom instruction as can be seen from their feedback. To conclude, the following are samples of the feedback:

“Learning the Nature of Science was very interesting to me. It brought a whole new experience.... If science is the truth, then why sometimes there are still questions to ask. Is the truth itself not perfect? If science is the truth, why it is sometimes against my religious belief? All the answers, I discover them in this subject… now I am able to see science in a new different view.’’ (Biology major)

“The lecturer has also shown us the picture that indicates a woman’s face. This picture actually was a combination of a flower and a butterfly and not a woman’s face. Through this image, one can come out with many theories to describe and explain the natural world... The lecturer also showed us the bar magnet. When he sprinkled iron over the bar magnet, the pattern of magnetic line was formed. It was so amazing and this pattern of lines formed due to different poles which attract and similar poles which repel each other. Other tangible products were shown to us in explaining the nature of science related to our study to better our understanding. From what we have learned, nature and process of science change over time when new observations are tested. So science is not always true which is called "the tentative nature of science." (Mathematics major)

REFERENCES

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program, *Journal of Research in Science Teaching, 44*(5), 653-680.

American Association for the Advancement of Science (AAAS). (1990). *Science for all Americans*. New York: Oxford University Press.

Beh, K. L. (2011). An innovative approach to teaching and learning about the nature of science: student's learning outcomes. *Asian Journal of University Education*, *7*(2), 35-38.

Buaraphan, K., & Sung-Ong, S. (2009). Thai pre-service teachers' conceptions of the nature of Science. *Asia- Pacific Forum on Science Learning and Teaching*, *10*(1), 1-22. Retrieved January 19, 2011, from http://www.ied.edu.hk/apfslt/v10_issue1/buaraphan/buaraphan13.htm#thir

Enger, S., & Yager, R. (1998). *The Iowa assessment handbook.* Iowa: Science Education Centre, The University of Iowa.

Jain, J., Beh, K. L., & Nabilah Abdullah.(2013). Pre-service teachers' conceptions of the nature of science. *Procedia - Social and Behavioral Sciences, 90*, 203-210. Retrieved November 11, 2013 from http://dx.doi.org/10.1016/j.sbspro.2013.07.083.

Khishfe, R., & Lederman, N. (2006). Teaching nature of science within a controversial topic: Integrated versus non-integrated. *Journal of Research in Science Teaching, 43*(4), 395-418.

Kosso, P. (1997). *Reading the book of nature: An introduction to the philosophy of science*. Cambridge: Cambridge University Press.

Liang L. L, Chen Sufen, Chen Xian, Osman Nafiz Kaya, Adams, A. D., Macklin, M., & Ebenezer, J.(2008). Assessing preservice elementary teachers views on the nature of scientific knowledge: A dual-response instrument *Asia-Pacific Forum on Science Learning and Teaching*, *9*(1), 1-20.

Lederman, N. G., & Abd-El-Khalick, F. (1998). Avoiding de-natured science: Activities that promote understandings of the nature of science. In W. McComas (Ed.). *The nature of science in science education: Rationales and strategies* (pp.83-126). The Netherlands: Kluwer Academic Publishers.

Tan, L. T. & Boo, H. K. (2003). Assessing the nature of science views of Singaporean pre-service Teachers. Paper presented at the Annual Conference of the New Zealand/Australia Association for Research in Education, Auckland. Nov-30- Dec 2003.

APPENDIX

Conception of Nature of Science Inventory

Name: Gender: Male Female

Please indicate with a tick (√) to what extent do you agree with these statements using the following: 1. Strongly agree 2. Agree 3. Not sure 4. Disagree 5. Strongly disagree

Please provide a brief explanation for the choice you have made.

		1	2	3	4	5
1	Experiments in science confirm scientific ideas. Explanation:					
2	Scientists use their imagination only at the early stage of investigation. Explanation:					
3	Science provides explanations with fact and proof. Explanation:					
4	Whatever content in science text is fact with certainty. Explanation:					
5	Theory becomes law with sufficient evidence. Explanation:					
6	Hypothesis-experiment-conclusion is the scientific method used by all scientists. Explanation:					
7	The same piece of evidence or data cannot be subjected to multiple interpretations. Explanation:					
8	Scientists are people with behaviour which is not normal as portrayed in most movies. Explanation:					