Examining Education Students' Nature of Science (NOS) Views

Asia Pacific Journal of Multidisciplinary Research
Vol. 3 No.5, 101 - 110
December 2015 Part IV
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com

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Date Received: October 9, 2015; Dare Revised: December 18, 2015

Abstract - *Teaching the Nature of Science (NOS) seems to be neglected despite the many developments in the teaching science. This is becoming especially important in the light of recent developments in pedagogy, as for example, more teachers adopt constructivist methodologies and computing technology which enables similarities that may blur the lines between models and reality. Consequently, identifying effective means for teaching the nature of science (NOS) has become a central focus for science education in the recent years. Accordingly, pre-service science teaching methods courses should promote NOS understanding. It is given that if science teachers are to present effective NOS instruction, they must have informed understandings of the NOS themselves and pedagogical content knowledge about effective NOS instruction. In this investigation, Bachelor of Secondary Education major in Physical Science students' NOS conceptions was assessed with adapted Views of the Nature of Science (VNOS) Form-C instrument originally designed by Lederman, Adb-El-Khalick, Bell and Shwartz (2002). Responses were analyzed into coded or thematic categories of 'naive', 'informed' and 'ambiguous'. Most participants held inadequate views in some aspects of NOS based on the result of the study. It was found out that significant portion of respondents possessed uninformed views. It was also noted that students from lower year levels had more ambiguous and uninformed views than those in the higher year level. Some implications for teaching and teacher education are also presented in this paper for discussion.*

Keywords: *Nature of science, aspects of science*

INTRODUCTION

Current reforms in science education emphasize teaching science for all, is an ultimate goal of developing scientific literacy [1]. In this view, science must go beyond simply teaching science as a body of knowledge. Teachers are now challenged to engage students in learning science in a much-broader sense—how scientific knowledge develops and evolves the very nature of knowledge itself. During the past 85 years, almost all scientists, science educators and science education organizations have agreed on the objective of helping students develop informed conceptions of nature of science [2], [3], [4]. Presently and despite their varying pedagogical and curricular emphases, there is an agreement among the major reform efforts in science education (American Association for the Advancement of Science [AAAS], 1990, 1993; National Research Council [NRC], 1996) about the goal of enhancing students' conception of NOS.

In general, nature of science refers to the key principles and ideas which provide valid description of science as a way of knowing as well as characteristics of developing scientific knowledge. Apparently, many of the core ideas are lost in everyday science classroom resulting in students learning misconceptions and faulty notions about how science is conducted (Targut, 2010).

NOS is a convergence of set of ideas that are most viewed in practical school setting and potentially most useful in developing scientific literacy [2],[3],[4]. Broadly speaking, then, the NOS refers to both the epistemology and sociology of science as a way of knowing, which includes the values and beliefs inherent in scientific knowledge [5] and understanding of social practices, the organization of science and how scientists perform scientific investigations [6]. This perspective underscores some aspects of science such as its tentativeness (TEN), empirical nature (EMP), theory-laden nature (THL), observation and inference (OI), socio-cultural embeddedness (SC), myth of a universal scientific method as well as the roles of scientific laws and theories (SLT), creativity and imagination (CI), distinction between scientific law and scientific theory (DLT). This definition is aligned with a basic understanding of the NOS which has been discussed in documents such as the Benchmarks for Scientific Literacy and the National Science Education Standards [7], [8], [9].

NOS in Education

Taking into consideration the findings about student understanding of the NOS, several different approaches for teaching the NOS have been developed. Lederman [5], [10], [9], [8] identify four approaches to NOS instruction based on where the instruction is situated: within-methods courses, within-science content classes, within-authentic science experiences (e.g., internships in research laboratories), and within- self-contained NOS courses or units. In large part, we hold most claims for any one of these approaches and against the others to be straw-man arguments. Smith and Scharmann [7] share the view of McComas et al. [8] and others that NOS understanding may best be enhanced when students learn informed views of the NOS, not just in one class, but when they encounter mutually consistent views of the NOS across more than one setting.

Alternatively, Abd-El-Khalick and Lederman [9] distinguish between implicit and explicit approaches to NOS instruction: Implicit NOS instruction assumes that students can learn the NOS by ''doing science.'' Students engage in science-based activities, but NOS issues are not specifically addressed. In contrast, explicit NOS instruction takes NOS learning to be a direct target, not a side effect of the learning experience. Aspects of the NOS are directly addressed with students. In keeping with a constructivist view of learning, explicit instruction has typically included extensive opportunities for students to reflect on their understandings of the NOS and how the readings, lectures, or other learning activities impact those understandings. According to Abd-El-Khalick and Lederman [9], the difference between the two types of instruction lies in the extent to which learners are provided (or helped to come to grips) with the conceptual tools, such as some key aspects of NOS, that would enable them to think about and reflect on the activities in which they are encouraged.

Research studies have employed a wide variety of materials and methods for use in explicit reflective NOS instruction, including reflective journal writing, small and/or large group lectures and discussions [11] teacher questioning, science-embedded activities, card sorts/card exchange games using NOS concepts, concept mapping, analysis of critical and typical teaching incidents, presentations by visiting expert speakers (scientists, philosophers, historians of science, classroom teachers who teach NOS, etc.), debates, readings, videos, developing lesson plans that address both science content and NOS, historical case studies, and comparing positions of philosophers, historians, and sociologists of science [8].

Enhancing teachers' conception of NOS

Science educators have also argued that it is self-evident that science teachers who teach the NOS must have an adequate NOS understanding themselves. Even when NOS is not a direct goal of teaching, the structure of the instruction likely sends implicit messages about the. In the absence of any systemic reform of science teaching, especially at the college level, it is highly likely that teacher candidates will continue to join teacher education programs with inadequate views of NOS (Stofflett & Stoddart, 1994). Science teacher education programs should continue their efforts to enhance prospective teachers' NOS views. However, there is a limit to what can be done within the context of teacher education programs given their already extensive and overly long agenda.

Given the multitude of objectives that such courses and programs often aim to achieve, it is difficult to imagine that more time can be allotted to dealing with NOS in these contexts. It is highly unlikely that science teachers' views of the scientific enterprise, views that have developed over the course can be effectively changed, updated or elaborated during a few hours, days or weeks for that matter.

As such, the efforts to enhance prospective teachers' NOS views undertaken within science teacher education programs need to be augmented with relevant coursework in other disciplinary departments (Brush, 1969; Matthews, 1994).

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com
Asia Pacific Journal of Multidisciplinary Research, Vol. 3, No. 5, December 2015

Intuitively, coursework in *philosophy and history of science* serve as primary candidates (Brush, 1989; Matthews, 1994; O'Brien & Korth, 1991; Robinson, 1969; Scheffler, 1973). Indeed, during the past 70 years, science educators (e.g., Conant, 1947; Duschl, 1990; Haywood, 1927; Klopfer, 1969; Klopfer &Watson, 1957; Monk & Osborne, 1997; Rutherford, 1964; Wandersee, 1992) have repeatedly argued that history of science can play a significant role in helping learners develop more adequate conceptions of the scientific enterprise.

OBJECTIVES OF THE STUDY

Generally, the study sought to measure the characteristics of the respondents' NOS views across level as measured by VNOS Form-C. Specifically, it measures the respondents' pattern of development in terms of NOS views from first year to fourth year and the corresponding degree of progress. It also sought to find out the aspects of NOS they have positive and negative progress. The result of this study shall be utilized in formulating instructional and curricular program that would target the enhancement of students NOS views.

MATERIALS AND METHODS

The study made use of a qualitative research approach to explore the NOS understanding of science education students, whether there is a general improvement from first year to fourth year college as well as in determining which aspect of NOS is considered most informed, naïve and ambiguous. In the research design, various data sources were utilized in the analysis of the participants' NOS-related conceptual constructs. The researcher acted as interviewer in a focus group discussion to elicit more responses from students.

Participants

In this investigation, all 165 students from Bachelor of Secondary Education major in Physical Science of the College of Teacher Education of the Pangasinan State University-Lingayen Campus were included from first year to fourth year. These students were handled by the same science teachers in almost all science subjects included in their curriculum.

The Research Instrument

The researcher adopted Lederman et. al's Views on Nature of Science (VNOS) Form-C, a modified and expanded version of the earlier VNOS Forms A and B. Lederman et.al (2002) developed a questionnaire focusing on aspects of the NOS [12]. An expert panel composed of three science educators, a historian of science, and a scientist examined the 10 items to establish their face and content validity. The panel had some comments and suggestions for improvement and the items were modified accordingly. In addition to assessing respondents' views of the NOS aspects targeted by the VNOS-B, the VNOS-C also aimed to assess views of the social and cultural embeddedness of science and the existence of a universal scientific method.

Validity of this instrument was tested with undergraduate and graduate college students, pre-service elementary teachers, and pre-service and in-service secondary teachers by the authors. A rubric was also used to classify student responses as ambiguous, naïve and informed. An electronic mail was sent to the authors by the researcher who sought for their permission and approval and without hesitation, one of the authors approved the researcher to use VNOS Form-C.

Procedures for collecting data

With 165 students, data gathering was only done in 1 week. Before administering the research instrument, the respondents were encouraged to write as much as they can in response to any one item and make sure to not miss answering all the questions and supply or provide supportive examples when asked to. They were also reminded that there is no right or wrong answer in the questions and that the purpose is to elicit their views of on some issues related to NOS. Lastly, they were assured that the survey result would not have any bearing to their term grades in science.

It was preferable to administer the VNOS Form-C under a controlled condition however, due to the nature of the open-ended VNOS, the researcher noticed that 40-50 minutes was not enough for most respondents to completely answer all the questions. After 70 minutes, all of the respondents were done.

On the second day, focus group discussion was done to elicit more responses from the students. In the discussion, students were asked to expound or elucidate some issues related to NOS.

Analyses of Data

For each question, a rating was given as naïve, informed or ambiguous using a rubric (see appendix). Though it was recommended by Lederman, et.al

(2002) that after the administration of the VNOS Form-C, a reasonable sample of the respondents should be individually interviewed where the respondents are to be asked to justify and elaborate their answers, clarify ambiguities and to explore respondents' line of thinking deeply, the researcher was not able to carry on with the interview part due to time constraints. Since the researcher had a bulky number of respondents, it was decided that it would be more efficient to just discard and not consider responses which could not be clearly interpreted without the respondent's further input. These responses were further classified under the "ambiguous" category. ANOVA was used to determine over-all difference between groups as well as Post Hoc Test to determine which specific group differed.

Establishing reliability of analyzing the data

Since there is only one researcher involved in the study, she sought help from her colleagues—the faculty of Natural Sciences Department of the same institution. It was found in this study that it is crucial to establish agreement or reliability of analyzing the data. An agreement was established by having all the members of the natural science department to independently analyze the responses. The researchers then compared the analyses being made on the data until consensus was achieved. As Adb- El-Khlaick *et. al*., (1998) mentioned, analyses of all questionnaire should only proceed after establishing such reliability.

RESULTS AND DISCUSSION

This study examined the BSE Physical Science students' views on the nature of science. Further, it examined the common NOS views that the students have within year level and across year levels and their corresponding pattern of progress. Also, it sought to find if there are misconceptions and ambiguities that students hold based on the 8-item question from the VNOS Form-C.

Table 1. Information on the respondents' NOS views per question

NOS View	Questions								
	1	2	3	4	5	6	7	8	%
Informed views	49	32	32	30	41	44	37	25	29.00
Naïve views	87	77	59	67	76	53	61	43	52.47
Ambiguous views	11	11	30	20	15	18	27	46	17.51
Total number of respondents **(N)= 165**									

The Table 1 reveals information on the respondents' NOS views per question, presenting the eight (8) different aspects of the NOS. It can be seen that more than one half of the respondents has naïve NOS views. The percentage of informed responses however was 29% and ambiguous responses which were discarded were, on average almost 18% of the responses.

The question where they obtained the most *informed* response was question number 1 (38%) which is all about their view of science as a discipline distinct from other disciplines like religion and philosophy. Question number 1 is empirical (EMP) in nature (see appendix) which states that science is partially based on observations of natural phenomena using the senses or extensions of the senses .While the question where they got the most *ambiguous* view was question number 8 (36%) which is science being universal and the embeddedness of culture and society in science. This item however is considered by respondents theory-laden (THL) that is based on personal values, disciplinary commitments, educational experience of scientists that influence their work.

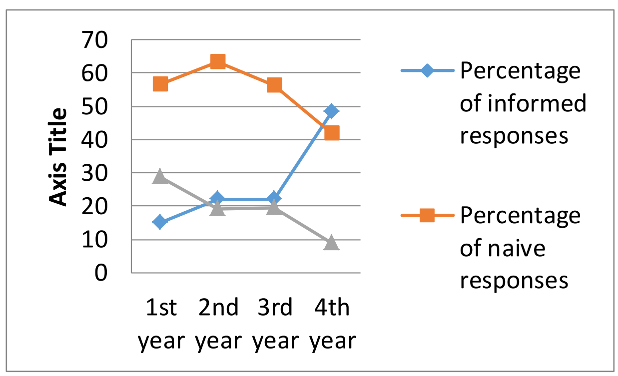

Figure 1. Trend/Pattern of Respondents' Informed, Naive and Ambiguous Responses

Figure 1 is the summary of respondents' informed, naive and ambiguous responses and the corresponding trend each year level represent. It can be clearly seen that for the informed NOS views, there was a slight increase or improvement from first year to second year. On the other hand, there was almost no increase with that of second year to third year (same case as ambiguous views), contrary from third year to fourth year where the highest increase or improvement was observed. For the naïve responses, it was an odd observation to note that there was an increase in the naïve NOS views from first year to second year as opposed to ambiguous views wherein a downward trend was observed.

Progression of Year-level NOS Views

Students' NOS views across year level provides information on the pattern of progress of each kind of view. The table below can be used to easily see these trends of progress that is intrinsic to year level NOS.

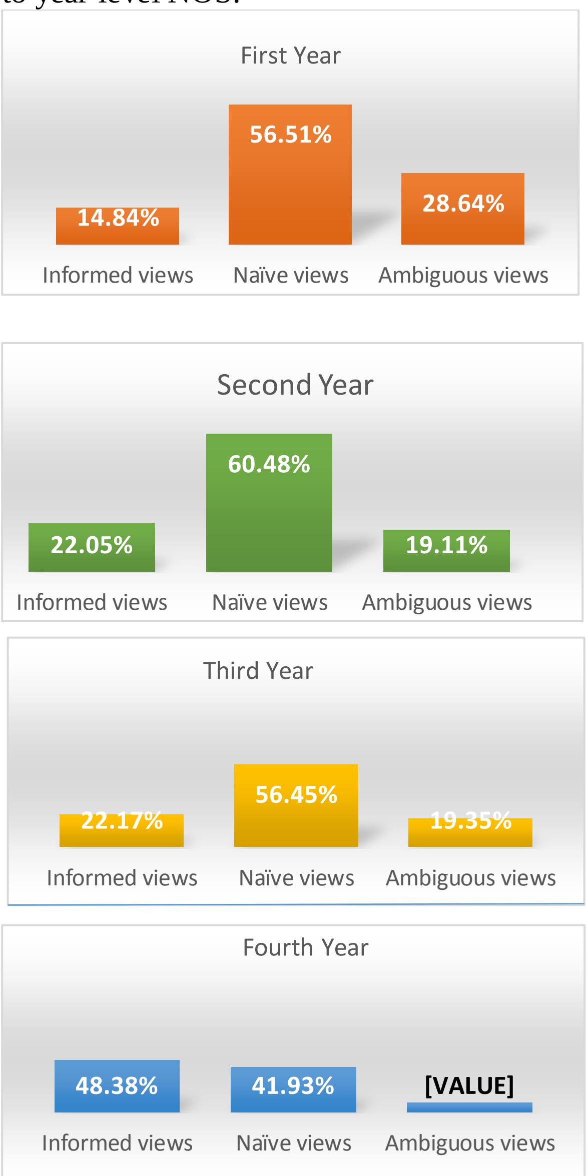

Figure 2. Progression of Year-level NOS Views

It can be seen from the figure 2 that there was a gradual but steady increase in the students' informed views. For the naïve views, there was an increase in the percentage from first year to second year but a decrease from second year to third year and fourth year. For the ambiguous views, there was a general downward trend except for a very small increase from second year to third year.

Aspects of NOS

Aspects of NOS such was tentativeness (TEN), empirical nature (EMP), theory-laden nature (THL), observation and inference (OI), socio-cultural embeddedness (SC), myth of a universal scientific method as well as the roles of scientific laws and theories (SLT), creativity and imagination (CI), distinction between scientific law and scientific theory (DLT) was also looked into in order to identify which aspect/s students have positive or negative progress

Table 2. Mean obtained by each year level) in terms of the aspects of NOS

NOS	Mean			
	1st	2nd	3rd	4th
NOS-EMP	1.67	1.72	1.77	1.93
NOS-TEN	1.44	1.5	1.46	2.13
NOS-OI	1.10	.81	1.11	1.76
NOS-THL	1.06	1.14	1.14	1.57
NOS-DLT	.83	.97	1.11	1.52
NOS-INF	.77	1.0	1.09	1.65
NOS-CI	.94	1.33	1.20	1.74
NOS-SC	.85	1.0	.97	1.72
Ave	1.083	1.181	1.231	1.759

Table 2 reveals the actual mean obtained by each group (year level) in terms of the aspects of NOS. It can be seen that the fourth year students obtained the highest total mean in all the aspects of NOS, to be followed by third year, second year and first year. However it can be noticed that the mean difference among first year, second year and third year was not remarkable versus fourth year.

Table 3. Significant Difference between year level and NOS (Analysis of Variance-ANOVA)

NOS	F-value	Significance	Remark
NOS-EMP	.998	.395	Not significant
NOS-TEN	7.093	.000	Significant
NOS-OI	11.091	.000	Significant
NOS-THL	4.279	.006	Significant
NOS-DLT	6.610	.000	Significant
NOS-INF	12.161	.000	Significant
NOS-CI	11.400	.000	Significant
NOS-SC	14.730	.000	Significant

Table 3 shows that almost all aspects of NOS are significantly correlated with year level except for aspect number 1 which is science has empirical nature (EMP). Empirical NOS science is partially based on observations of natural phenomena using the senses or extensions of the senses. This is probably due to lack of laboratory activities in science as well as field work that could enhance students' observational and experimental skills [11] in generating empirical data.

Table 4. Significant difference in students' NOS views across year levels

ANOVA

Percentage

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.827	3	2.609	.005	.999
Within Groups	3869.888	8	483.736		
Total	3877.714	11			

One question that the study sought to find out is whether students' NOS views across year levels do significantly different or not. With a significance level at 0.05, one-way ANOVA was utilized using SPSS.

With the significance level (p-value = 0.999) of the ANOVA test of SPSS, it shows that there is a significant difference between the science views of the education students across year level. It means that students view of NOS change as they progress from first year to higher years in college.

Table 5. The Post Hoc Test

Multiple Comparisons

Dependent Variable: Percentage
Tukey HSD

(I) YearLevel	(J) YearLevel	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.46667	17.95802	1.000	-58.9746	56.0412
	3.00	.67333	17.95802	1.000	-56.8346	58.1812
	4.00	.27000	17.95802	1.000	-57.2379	57.7779
2.00	1.00	1.46667	17.95802	1.000	-56.0412	58.9746
	3.00	2.14000	17.95802	.999	-55.3679	59.6479
	4.00	1.73667	17.95802	1.000	-55.7712	59.2446
3.00	1.00	-.67333	17.95802	1.000	-58.1812	56.8346
	2.00	-2.14000	17.95802	.999	-59.6479	55.3679
	4.00	-.40333	17.95802	1.000	-57.9112	57.1046
4.00	1.00	-.27000	17.95802	1.000	-57.7779	57.2379
	2.00	-1.73667	17.95802	1.000	-59.2446	55.7712
	3.00	.40333	17.95802	1.000	-57.1046	57.9112

Post hoc test was run to confirm where the differences occurred between groups. This test was used only when there is an overall significant difference in group means (i.e., a significant one-way ANOVA result).

Post Hoc test by the ANOVA using Tukey's Multiple Comparison Test shows that the pair-wise comparisons among the four year levels are all significant in all levels. This shows that science teaching and learning process is a very dynamic experience that allows changing of students' NOS views from lower to higher level in college.

Analysis of students' answers per question

The following is question-by-question analyses of the typical responses from the students and a brief explanation of how the figures on the tables came to be what they were. Likewise, some sample answers reflected that of students' typical responses in the focus group discussion. The subsection header contains a quotation verbatim from the respondents' views. This section also includes answers on the questions above.

Question number 1- NOS Aspect: Empirical

What in your view is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g. religion, philosophy)?

Sample answer:

"Science is a systematized body of knowledge that involves inquiry, discovery and development of new technology but in religion and philosophy, it is personal belief, reasoning and emotions most of the time".

Many respondents mentioned about science as a systematized body of knowledge. Here they believe that science's very nature of tentativeness allow further inquiry and discovery of new knowledge and technology. However, their view of philosophy and religion is only limited to being governed by personal background and environment that shapes the persons' belief. However, this is the question where students got the highest percentage of "informed" response.

Question number 2 -NOS Aspect: Tentative

Does the development of scientific knowledge require experiments?

Sample answer

"We need to experiment to discover facts. It is also needed for the development of skills. Observation alone is not enough to test the validity of the data".

Most of the students expressed their "naïve" views here. Several points were mentioned about the need of testing or verifying the accuracy and veracity of an information through experimentation. However, the students only view an experiment as it is being conducted in the classroom setting—has time frame, with a fixed structure and with well-defined procedures to be followed. They also gave importance of the reason why experiments are conducted in the classroom as a strategy for effective science learning tool, not as a scientific enterprise that meets the criteria of empirical validity and to collect accurate data which can support of oppose a claim. This misconception of science has the potential to become an important stumbling block to effective science education.

Question No. 3 -NOS Aspect: Observation and Inference

Science textbooks often represent the atom as a central nucleus composed of protons and neutrons with electrons orbiting that nucleus. How certain are scientists about the structure of the atom? What specific evidence, or types of evidence, do you think scientists used to determine what an atom looks like?

Sample answer

"No one has ever seen an atom himself. No atomic microscope is invented for this purpose. Atomic properties were purely based on experiments conducted like the alpha- scattering experiment of Rutherford and other similar tests by Goldstein and Thompson. Scientists just make their representations and models".

Question number 3 revealed that students are knowledgeable of various scientists and their great work that paved the way to the development of atomic properties like the experiment of Rutherford. They are also aware that up this age of nanoscience, no instrument has been developed to actually see an atom. However, it is clear that the sample of respondents were not aware of the fact that before scientific models and representations are made, numerous testing of the hypothesis are being done by not only one scientists but of a group of scientist before even an initial version of a model is presented.

Question No. 4- NOS Aspect: Tentative distinction between scientific theory and law

Is there a difference between a scientific theory and scientific law? Illustrate your answer with an example.

Sample answer

"Theories are questionable and can be changed while laws are not questionable and cannot be changed. Theory is just a plausible proposal while law is already an established fact".

This is the question the provided the most uniform answers from the respondents. They view scientific theories as tentative, debunkable and verifiable unlike laws which are ultimate and unverifiable anymore by any means. Highly significant number of respondents took the uninformed view, in effect falling for the "laws-are-mature-theories-fable" as coined by Rubba, Horner and Smith (1981). It was not surprising that many respondents fell for this fable, for long it has been promulgated even in science textbooks today. Not even one answer from the respondents mentioned laws as tentative as well. They believe that no scientific law can be superseded by new knowledge.

Question No.5 - NOS Aspect: Tentative distinction between scientific theory and law

After scientists have developed a scientific theory (e.g. atomic theory, evolution theory) does the theory ever change?

If you believe scientific theories do not change, explain why. Defend your answer with examples.

If you believe scientific theories do change:

a. Explain why theories change
b. Explain why we bother to learn scientific theories. Defend your answer with examples.

Sample answer

"*Theories do change especially if there is a new discovery or evidence. Theories need to be studied in order to develop new information or new theories. We study theories because they may be are true*".

It was very much evident in the respondents' answer that they really think that theories do change when a new and more accurate knowledge has been generated. However it was also reflected in the respondents' answers that since overpowering or debunking of an existing theory are not a usual case. Most of them made mentioned of the Geocentric theory replaced by Heliocentric theory that took a hundred of years before it was replaced by a more sound theory. Due to this, a number of them thought that most theories are more or less factual than not so they are worth studying in classrooms.

Question No. 6-NOS Aspect: Tentative, Inferential, Creative and Imaginative distinction between scientific theory and law

Science textbooks often define a species as a group of organisms that share similar characteristics and can be interbred with one another to produce fertile offspring. How certain are scientists about their characterization of what a species is? What specific evidence do you think scientists used to determine what a species is?

Sample answer

"*They use observation of physical characteristics, movement and function of parts of species. They can also use base from genetic composition and evolutionary path as well as DNA analysis because each organism has a unique DNA blueprint".*

It can be noted from the response above that respondents' are aware that scientists use a variety or multitude of scientific techniques before making a scientific judgment or assessment. They are knowledgeable of some methods conducted that will ensure scientific veracity, accuracy and clarity of ideas or claims.

Question No. 7 NOS Aspect: Creativity and imagination

Scientists perform experiments/ investigations when trying to find answers to the questions they put forth. Do scientists use their creativity and imagination during their investigations?

If yes, at which stages of the investigation do you believe that scientists use their imagination and creativity: planning and design; data collection; after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.

If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com
Asia Pacific Journal of Multidisciplinary Research, Vol. 3, No. 5, December 2015

Sample answer

"Like when an apple fell on Isaac Newton, he used his imagination in relating what he observed with a Physics principle. Yes scientists use their creativity and imagination because they are bound to invent something unique and useful to mankind".

Some of the respondents thought that creativity is used in planning and starting up the experiment and a little bit of imagination to visualize the future output of their work. In some cases, they thought creativity and imagination cannot be used in the process because they are bound to follow what is in the procedure and were advised to adhere only to what the method says. Again, they go back to their classroom laboratory experience when they are supposed to follow only a given set of rules and procedures without the opportunity to inject creativity. Also, a number of uninformed responses mentioned that creativity can be incorporated in the presentation of result for aesthetic purposes—in order to make the product more appealing to the public. Lastly, concerning the creative nature of scientific investigations, most of the respondents did not seem to think that creativity and imagination were required at all steps. It is understandable that majority of the students think this because no alternatives are usually given to them when doing experiments except when asked to improvise certain apparatus.

Question No. 8 NOS Aspect: Socio-Cultural Embeddedness

Some claim that science is infused with social and cultural values. That is, science reflects the social and political values, philosophical assumptions and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, philosophical, values and intellectual norms of the cultured which it is practiced. If you believe that science reflects social and cultural values, explain why. Defend your answer with examples. If you believe that science is universal, explain why. Defend your answer with examples.

Sample answer

"*Science is universal and thus not affected by social and political norms around us. Like human genome project was collectively worked together by people in the world. Scientific knowledge is used by people all around the world regardless of culture, religion, political system etc.".*

This question gave the most ambiguous answer. Only a few respondents had a similar idea to the one above (which is considered to be informed). Most of the students think that science is universal because we study the universe and the characteristics of all the planets in the cosmos and that all countries have a pool of scientists in them.

CONCLUSION

Most of the respondents have naïve NOS views. They may have basic idea or knowledge about the concept or subject but not that in depth or well elaborate.

Respondents are most informed on the concept that science is distinct from other disciplines (*i.e*. Philosophy and Religion). This could be explained by the unique and distinguishing characteristics of science. On the other hand, respondents are least informed on the idea that science is universal and that science is strongly interlinked with our culture and tradition in the society.

Students in the higher level have better NOS views than those with lower level. Fourth year students have the most informed views while the first year students have the least informed (ambiguous) views. Generally, both naïve and ambiguous NOS views that students hold in lower years improve as they move to upper year. There was also positive improvement in students' informed views as they move from lower to higher years.

There was a significant improvement in all aspects of science across year levels except for one aspect that science being empirical in nature. This is due to lack of experience doing actual

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Asia Pacific Journal of Multidisciplinary Research, Vol. 3, No. 5, December 2015

observational and experimental-based activities that generates empirical data.

A notable observation was seen among first year, second year and third year students. There is a very small difference of number of respondents with informed views as compared to the fourth year students. The case was seen in terms of the aspects of NOS, they are far more elaborate to express their knowledge on these aspects as observed in their written answers and in the focus group discussion. However, this is quite expected as they have undergone more exposure to activities in line with NOS in both their science classroom and in field study sessions.

RECOMMENDATION

Considering the time frame to conduct this study, the researcher was not able to carry on with the supposed interview method that will that will further clarify or elaborate ambiguous responses. The researcher is suggesting further research that will determine the definite views of NOS by the students in the university across all programs through quantitative analysis. Also, it is good to take into consideration science teachers' views of NOS in the study as it can be correlated with the students' views of NOS.

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