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COMPARISON ON VIEWS OF NATURE OF SCIENCE BETWEEN MATH AND PHYSICS STUDENTS

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Abstract. *University lecturers stress the importance of science and non-science students developing informed views of nature of science. However, few previous researches have conducted to explore students' NOS views within specific majors. Consequently, this research used the questionnaire of VNOS-D (View of Nature of Science, the version D) to assess the views of nature of science between math and physics students. From the survey of 311 students, it was found that both math and physics students scored relatively lower on the subjective and social & cultural dimension than others. However, on the tentativeness dimension, the third year and the fourth year physics students showed significantly more sophisticated views than math counterparts. In addition, the differences across grade levels were found on the observation & inference dimension in both math and physics major groups. Some possible explanations were provided. The findings indicated that majors and grade levels influenced the views on some special dimensions of NOS.*

Key words: *math and physics students, university science education, views of nature of science.*

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Introduction

University lecturers share the common goal of helping students develop their scientific literacy, it is crucial that the students develop scientific literacy in order to improve their learning performance in science courses, the ability to understand instructions from their teachers and be capable of understanding the surrounding world, taking personal, workplace, and community decisions and acting as informed citizens appreciating scientific norms and the moral issues associated with science (Smith, Loughran, Berry & Dimitrakopoulos, 2012; Torres & Vasconcelos, 2015). Understanding of the nature of science (NOS) is often defended as being a critical and primary component of scientific literacy (Abd-El-Khalick & BouJaoud, 1997; Liu & Lederman, 2007; Wang & Zhao, 2016). The development of students' conceptions of the Nature of Science has been a concern for many years. Nature of science involves a wide variety of topics related to the history, philosophy, and sociology of science. Nature of science describes what science is, how it works, how scientists operate and how society influences and is influenced by the scientific enterprise, merging aspects of history, sociology, philosophy of science and psychology (McComas, Clough & Almzroa, 1998). Despite there is no consensus on its definition of NOS, there is a general agreement of important elements of NOS that should be included in science class, which play a key role in scientific literacy formation (Khishfe & Lederman, 2006). These characteristics are often used by science educators to refer to issues such as scientific knowledge is tentative; empirically based; theory-laden; the product of human inference, creativity and imagination; and socially and culturally embedded (Liu & Lederman, 2007).

Most of nature of science study focused on primary, secondary and high school students and their teachers (Bell, Blair, Crawford, & Lederman, 2003; Kang, Scharmann & Noh, 2005), Some of the studies focused on scientists' views of NOS (Schwartz & Lederman, 2008; Wong & Hodson, 2009; Aydeniz

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& Bilican, 2014). Deng, Chen, Tsai & Chai (2011) critically reviewed more than one hundred of studies regarding students' views of nature of science. Among these selected papers, the studies investigating undergraduates' views of NOS were relatively few. Most of the current studies were conducted within Western countries; therefore, it is improper to generalize the findings of these studies to elsewhere in the world, and especially China. Cultural influence in students' views of NOS has been identified in some studies. Sutherland & Dennick (2002) have reported that students from non-Western countries seemed to hold more objectivist/empiricist views of NOS than those from Western countries. It was found that Omani university students are more likely to accept scientific authorities as the basis of scientific truth than the US students (Karabenick & Moosa, 2005). Although a number of studies (Liu & Tsai, 2008; Liang, Lee & Tsai, 2010; Chai, Deng & Tsai, 2012) have investigated students' views of NOS in the oriental culture context, however, these studies seem to be mainly focused on students from Chinese Hong Kong or Chinese Taiwan. Research about mainland China students' views of NOS is rare. Due to the unique Confucian philosophical tradition and the current dominance of Marxism, exploring mainland Chinese students' views of NOS is an important supplement for the international compare education. Inspired by Western countries, mainland China started to highlight NOS as a primary component of scientific literacy in 2001. However, the ideology guiding China education is still premised upon the dialectical materialism (Wei & Thomas, 2006). Marxism believes that the material world is the only reality, it is independent of our mind, it is the source of mind, and mind is just a reflection of the material world (Engels, 1976).

At the university level, the relation between students' majors and their views of NOS is another key problem to researcher. Relevant research findings indicated that university students' views of NOS may be associated with their academic majors (Dagher & BouJaoude, 1997; Edmondson & Novak, 1993). The disciplines that students select as their major fields of study constitute academic sub-contexts within which a substantial portion of students' academic experiences take place (Paulsen & Wells, 1998; Elby & Hammer, 2001; Samarapungavan, Westby & Bonder, 2006). Ryder, Leach & Driver (1999) compared views of NOS of eleven senior science students in different disciplines at the University of Leeds, they were interviewed about NOS at the beginning and end of their work on their final year science projects. The findings showed that discipline influenced students' image of science development. However, Pomeroy (1993) used a survey to compare the NOS beliefs of physical scientists, biologists, environmental scientists, and social scientists. There was no statistically significant difference between individuals of different scientific disciplines. However, such limited studies were not adequate for capturing the full complexity of students' views of NOS in different disciplines. Even some research findings were unreliable, for example, the results of investigation between science and non-science majors from Liu & Tsai (2008) showed that undergraduates' epistemological views of science do not differ significantly. In this study, those from the departments of physics, chemistry, mathematics, biology, and science education were categorized as science majors. Mathematical theorems and formulas are obtained by logical derivations which presume axiomatic systems. According to the definition of Popper (2005), mathematics is not a science because it does not require an experimental test of its theories and hypotheses, namely not experimentally falsifiable. In general, physics, chemistry and biology are classified as science. Scientists tend to focus on solving concrete problems in the field of mathematics or during experiments. When a new science theory proposed, experimental tests will be conducted in order to examine the new theory. It is important to note theory is accepted tentatively. The theory can confront crisis when researchers encounter its limitations.

Research Focus

Mainland Chinese is influenced by the Oriental Confucian culture and Marx's materialism. So this is an interesting research in mainland China. The purpose of this research was to explore NOS views of a sample of undergraduate students majored in math and physics. Since the students of two majors had different academic experiences respectively, the researchers assumed that the NOS views of students from two different majors also would be different. It was anticipated that students in physics science would have more informed views of NOS.

Two primary questions guided the research:

1. What are the differences, if any, among math majors' and physics majors' views of NOS?
2. What are the grade-level differences, if any, among math majors' and physics majors' views of NOS?

Methodology of Research

General Background of Research

The aim of this research is to explore the NOS views of a sample of undergraduate students with different grades and different majors (math and physics) in a public university located in northeastern China. The students' views of NOS were compared between the two majors as well as among four grade levels. The research was conducted during the sixth week of the autumn semester in 2016.

Sample of Research

The physics department and the math department altogether have 311 students; they all participated in this research. These students were enrolled in four-year full-time degree courses and aged from 18-22 years. Finally 302 students (68% males and 32% females) completed the questionnaire for analysis. The numbers in terms of students' major and grade-level were presented in Table 1.

Table 1. The numbers in terms of students' major and grade level.

	First year	Second year	Third year	Fourth year	Total
Math	39	41	38	39	157
Physics	37	37	35	36	145
Total	76	78	73	75	302

Instrument and Procedures

The instrument was the Views of the Nature of Science questionnaire (VNOS-D), it has been widely used with excellent reliability and validity (Lederman, 2007). The VNOS-D consists of seven open-ended questions that help identify understandings of creativity (Q1), observation & inference (Q2), subjective (Q3), tentativeness (Q4), empirically based (Q5), theories & laws (Q6), and social & cultural (Q7). The questionnaires were selected because the nature of open-ended question allows students to answer in their own words. Since English is not the native language for Chinese people, a translation was needed. The translation was carefully performed by a class of two experienced science education professors and two English professors. The translation into Chinese was validated by 32 students. All 32 students were asked to do both Chinese and English versions of the questionnaire to avoid the influence of language differences. The Chinese version was given first and then the English one. With minor adjustment of the translation, all of the students arrived at the same answers for each question in both the Chinese and English versions. Students were informed before administrating the questionnaire that there were no right answers to any of the questions and that their course grades would not be affected by the results of the questionnaire.

Data Analysis

Student responses to the VNOS-D questionnaire were collected, scored and finally categorized as informed (score of 3), transitional (2) and naive (1), according to the guide developed by Lederman, Lederman, Kim & Ko (2006). To seek a higher level of reliability, only the first author scored the open-ended responses independently. Mean scores for each component of questionnaire were calculated, and the effects of grade-level and type of major (math and physics) were analyzed with ANOVA. Descriptive and inferential statistical procedures were performed using the SPSS software.

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Results of Research

Major Comparisons of Views of NOS

ANOVA tests of four grade levels among two major groups of participants were shown in Table 2. It was discovered that the third year and the fourth year physics students showed significantly more sophisticated views of NOS than math counterparts did on the tentativeness(Q4) dimension ($F=4.97$, $p<0.05$; $F=5.30$, $p<0.05$). Although the physics students in all four grades scored higher than the math students respectively on the subjective (Q3) and empirically based (Q5) dimension, no significant difference was found. In addition, math and physics majors scored relatively lower on the subjective (Q3) and social & cultural (Q7) dimension than others. In addition, the dimensions of creativity (Q1) and observation and inference (Q2) didn't have significant difference.

Table 2. Major comparisons of views of NOS.

	Math	Physics	F
Q1			
First year	2.28	2.19	0.78
Second year	2.27	2.24	0.06
Third year	2.24	2.26	0.03
Fourth year	2.26	2.25	0.01
Q2			
First year	2.08	2.05	0.03
Second year	2.07	2.05	0.02
Third year	2.18	2.29	0.54
Fourth year	2.30	2.33	0.04
Q3			
First year	1.74	1.81	0.42
Second year	1.76	1.84	0.60
Third year	1.74	1.80	0.40
Fourth year	1.77	1.83	0.28
Q4			
First year	2.12	2.14	0.02
Second year	2.12	2.14	0.01
Third year	2.13	2.40	4.97*
Fourth year	2.18	2.42	5.30*
Q5			
First year	2.28	2.41	1.27
Second year	2.29	2.38	0.63
Third year	2.29	2.40	0.97
Fourth year	2.28	2.42	1.49
Q6			
First year	2.05	2.03	0.03
Second year	2.02	2.00	0.04
Third year	2.05	2.06	0.01
Fourth year	2.03	2.03	0.01

	Math	Physics	F
Q7			
First year	1.72	1.78	0.38
Second year	1.76	1.81	0.26
Third year	1.76	1.76	0.01
Fourth year	1.74	1.78	0.12

**p<.05.*

Grade Level Comparisons of Views of NOS

The Results of ANOVA of the two major groups among four different grade levels are summarized in Table 3. It shows that the differences across grade levels were significant on the observation & inference (Q2) dimension in both math and physics major groups ($F = 1.16$, $p<0.05$; $F=2.77$, $p<0.05$; respectively). Namely, due to the increase of grade level, math and physics students have more informed views related to the observation & inference (Q2) dimension. It needs to point out that on the tentativeness (Q4) dimension, significant differences among grade levels were only found in physics major group. Although the grade-level differences existed in math major group, no significant difference was found.

Table 3. Grade level comparisons of views of NOS in two majors.

	First year	Second year	Third year	Fourth year	F
Q1					
Math	2.28	2.27	2.24	2.26	0.06
Physics	2.19	2.24	2.26	2.25	0.18
Q2					
Math	2.08	2.07	2.18	2.30	1.16*
Physics	2.05	2.05	2.29	2.33	2.77*
Q3					
Math	1.74	1.76	1.74	1.77	0.03
Physics	1.81	1.84	1.80	1.83	0.07
Q4					
Math	2.12	2.12	2.13	2.18	0.11
Physics	2.14	2.14	2.40	2.42	3.56**
Q5					
Math	2.28	2.29	2.29	2.28	0.01
Physics	2.41	2.38	2.40	2.42	0.04
Q6					
Math	2.05	2.02	2.05	2.03	0.03
Physics	2.03	2.00	2.06	2.03	0.09
Q7					
Math	1.72	1.76	1.76	1.74	0.06
Physics	1.78	1.81	1.77	1.78	0.06

p<.05. ,p<.01.*

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Figure 1 and Figure 2 demonstrated the detailed proportion changes on the observation & inference (Q2) and the tentativeness (Q4) dimension respectively. The movements from the "naive" to the "transitional" or "transitional" to "informed" were obvious.

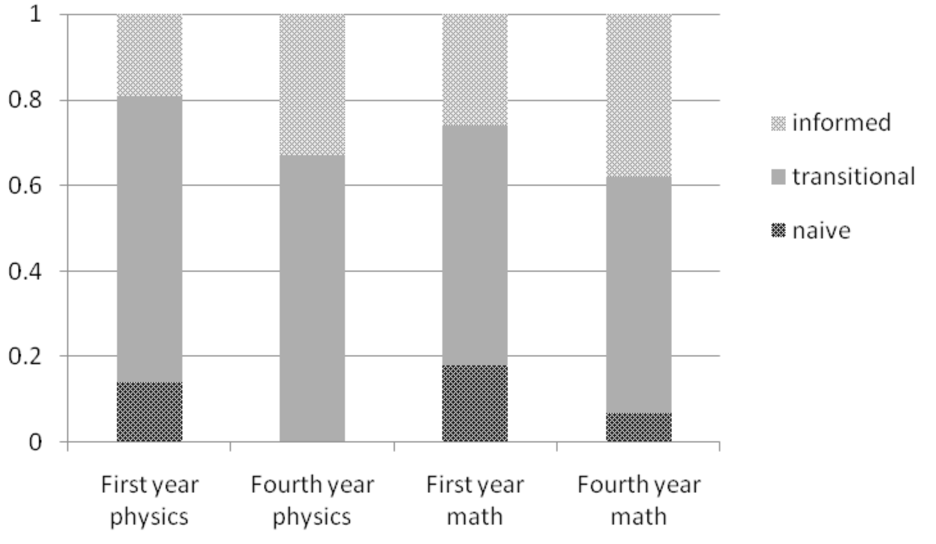

Figure 1: The movement on the observation & inference (Q2) dimension.

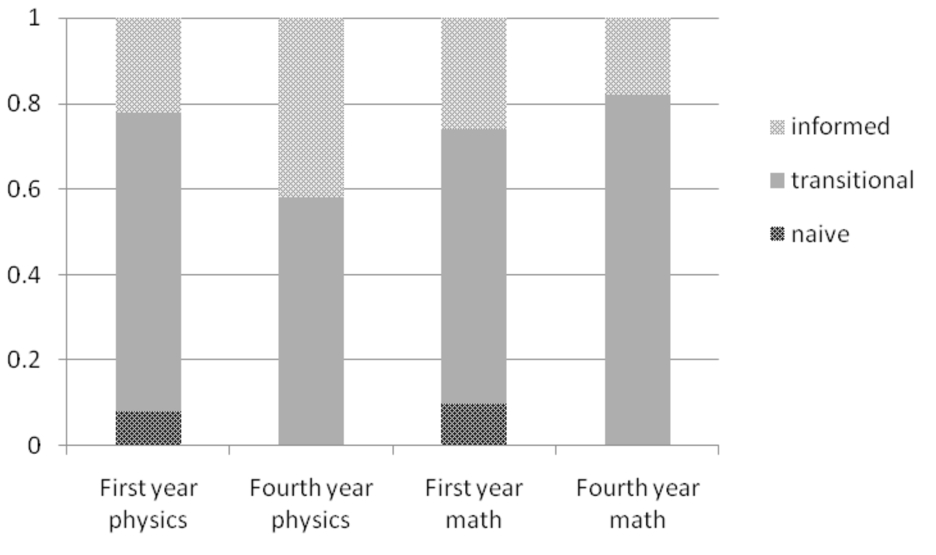

Figure 2: The movement on the tentativeness (Q4) dimension.

It was found movement from the "naive" to the "transitional" or "transitional" to "informed" happened for a larger percentage of students in both majors on the observation & inference (Q2) dimension. The movement on the tentativeness (Q4) dimension for physics students is obvious, especially in "naive" or "transitional" to "informed", however, similar results were not found to math students.

Discussion

By now, very few studies have examined NOS views of undergraduate students within specific majors. This research looked specifically at math and physics majors. The results indicated that the NOS views of students from math and physics were similar in general, but different on some dimensions of NOS.

It was discovered that the third year and the fourth year physics students showed significantly more sophisticated views of NOS than math counterparts did on the tentativeness (Q4) dimension. Several possible explanations for this result are: the physics students in the third year and fourth year touched the modern physics, and learned more about the history of the development of physical science theory and recognized the limitations of many classical theories, these theories were replaced by new theories. For instance, the ultraviolet catastrophe (also called the Rayleigh–Jeans catastrophe) of late 19th century/early 20th century contradicted the principles of classical physics. The old theory could not provide an answer to the catastrophe, and was replaced by the new quantum theory (Kuhn, 1978). Like other scientific theories, physics theories are accepted tentatively (Tsai, 2006). While mathematical theories obtained by logical derivations are certain. As Einstein said, one reason why mathematics enjoys special esteem, above all other sciences, is that its laws are absolutely certain and indisputable, while those of other sciences are to some extent debatable and in constant danger of being overthrown by newly discovered facts (Mayer & Holms, 1996).

In addition, this research also revealed that both math and physics majors scored relatively lower on the subjective (Q3) and social & cultural (Q7) dimensions than others. Nobody held informed views on the subjective (Q3) and social & cultural (Q7) dimensions. In the research of Hanuscin, Akerson & Phillipson-Mower (2006), it was also found students' failure to understand how an individual's subjectivity might influence their science knowledge construction. Scientists' attitudes, beliefs, prior and background knowledge, and experience affect the research questions and the data-acquisition, and interpretation processes in addition to well-known science paradigms. Scientists acquire their knowledge as human beings rather than as detached or objective mechanical beings (Lederman, 2007; Ben-Ari, 2005; McComas, 2003). The subjective (Q3) dimension seems to reflect students' struggle with the paradox whether science is objective or subjective. Such "mixed" views were also recognized in some studies (Chai, Deng, Wong & Qian, 2010; Chai, Deng & Tsai, 2012). Scientific enterprise and scientific knowledge can be affected by social and cultural factors (Buaraphan, 2009). One example to explain the culture influences in science: it was more than a100 years after Copernicus that his ideas were considered because religious beliefs of the church sort of favored the geocentric model (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002). The results of social & cultural (Q7) dimension indicated that students' understanding of this respect was quite inadequate. It is likely to be related to the predominance of the Marxist dialectical materialism in China (Wei & Thomas, 2006). Marxism believes that the material world is the only reality, it is independent of our mind, it is the source of mind, and mind is just a reflection of the material world (Engels, 1976). Influence by the Marxist tenets, dialectical materialism suggests that science is objective and not affected by social and cultural context.

Some differences were also found between students in the beginning and in the end of their courses. It showed that due to the increase of grade level, math and physics students have more informed views related to the observation & inference dimension. These results seem to indicate that learning experiences at the university level can exert some influence on the development of students' views of NOS during their four years of discipline training. The learning process mainly consisted of logical reasoning, experimental operation and observation. Some relevant studies have shown the similar results of effect of grade (Tsai, 2006). Huang, Tsai & Chang (2005) reported that Taiwan sixth graders express more informed views than fifth graders on some dimensions of nature of science, but not all dimensions.

Conclusions

The results indicated that the NOS views of students from math and physics were similar in general, they all scored relatively lower on the subjective (Q3) and social & cultural (Q7) dimension than others, this is due to the unique Chinese Confucian philosophical tradition and the current dominance of Marxism. One student said: The world is material, the creation and development of scientific knowledge should not be influenced by scientists' perspective, bias, and/or attitude. It was also discovered that the third year and the fourth year physics students showed significantly more sophisticated views of NOS than math counterparts did on the tentativeness (Q4) dimension ($p < 0.05$). It's because physics and math students' academic experiences were different. The physics students in the

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third year and fourth year touched the modern physics and recognized the limitations of many classical theories. However, mathematical theory knowledge obtained by math students was absolutely certain and indisputable. One physics student said: Scientific knowledge can change over time including theories and laws. The atomic model is designed by scientist's imagination from the experimental results. The model can be changed if they have new information. It seems that new data is the only thing that would have someone changes their theory. In short, the findings of the research indicated that majors and grade levels influenced the views on some special dimensions of NOS. Due to the sample size, this research is small, more research need to be conducted in the future.

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