What Do Pre-Service Science and Mathematics Teachers' Views about Scientific Theories and Laws?

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ABSTRACT

This study aimed to investigate pre-service science and mathematics teachers' views about theories and laws and compare their beliefs about them. The participants were 75 pre-service teachers (32 science and 43 mathematics). Participants were engaged in different NOS activities through one semester that explicit reflective approach to improve their views. For data collection, Views of Nature of Science (VNOS-C) questionnaire [6] was used for pre and post tests to determine participants' initial views. Semi-structured interview was undertaken with 8 participants as post tests in order to help uncover the participants' views. Each of the participants' pre and post tests responses were analyzed and coded as "naïve", "have merit" and "informed". The results revealed that majority of both groups have naive view according to pre-test results. Meanwhile, the post test results indicated that science teachers' views were more informed than mathematics teachers' views after explicit reflective approach.

Keywords: Nature of science, Pre-service Science Teachers, Pre-service Mathematics Teachers, Scientific theory and law.

1. THEORETICAL FRAMEWORK

Scientific theories and laws have distinct characteristic of knowledge. Their roles in science are different and there is no hierarchical relationship between them [1]. Theories never become laws even with additional evidence. Laws are principles, generalizations or patterns in nature and theories are the statements of those generalizations [7] (e.g. The Law of Gravity). Scientific theories are the products of scientific logical processes like laws. They are inferences generated as a result of the relationship between the structures of the natural phenomena [5]. There is no possibility to test the theories directly (e.g. Big Bang Theory). Theories are only supported by the data and different evidences. Scientists proposed new theories only checking out these theories against the verified data. The reliability of the theories increase when there is such agreements between predictions, experimental evidences, and the data. Popper (1983) [8] concluded that a hypothesis, or theory is "scientific" only if it is, among other things, falsifiable. That is, falsifiability is a necessary (but not sufficient) criterion for scientific ideas. He also stated that unfalsifiable statements are non-scientific, although not without relevance. Differences between observations and inferences revealed the distinction between scientific theories and laws.

The nature of science concept has been proposed as an important learning outcome for science education; however, research studies have consistently shown that both students and teachers have naïve ideas about the structure of epistemological scientific knowledge [7], [5]. McComas (1998) [7] has listed mutual misconceptions on NOS made by both pre-service teachers and in-service teachers as hierarchical order between hypothesis, theory and law, certainty of scientific laws and ideas. The false statements from the books and other sources, the educators' lack of knowledge and insufficient opportunities to develop themselves cause the formation of these misconceptions. Irez (2009) [4] examined the conception of the nature of science in five high school biology textbooks. He reported that the books are generally inadequate in terms of their vision of NOS. Furthermore, fundamental aspects of the nature of science have been found to be deficient in textbooks.

The science and mathematics are two important courses in teaching nature of science and when compared with other disciplines, these two courses classified in the same class generally. However, the close relationship between math and science is a little bit ignored and when the subject is nature of science, this issue is considered only in terms of science lessons. Many detailed studies have done about the nature of science opinions of science teachers however, only a small number of studies have examined mathematics teachers' views on nature of science.

According to AAAS (2001) [2], science supports mathematics to create interesting problems, mathematics also supports science with its mathematical tools (numbers, symbols, graphics..). Mathematics defined as the language of science. Mathematics and science have many common features, for this reason, we must understand mathematicians NOS conceptions, beliefs and/or views of the relevant domains and topics. For that reason; one goal of this study has been to explore the views of pre-service science and mathematics teachers' on the scientific theories and laws aspect of NOS. A second goal was to better understand how pre-service science and math teachers' branch affiliations affect their own concept of the nature of science. A third goal was to compare NOS views of pre-service science and math

teachers' which have similar mental structures and thought systems, constitutes the importance of this study.

2. METHOD

Sample and Data Resources

A total of seventy-five pre-service elementary teachers (32 science and 43 math) participated in this study. Data were obtained from the Views of Nature of Science Questionnaire-Form C (VNOS-C) developed by Lederman, Scharwartz, Abd-El-Khalick, and Bell (2002) [6]. The VNOS-C consists of ten open-ended questions which assessing NOS views of the students. This study has only three relevant questions about theories and laws within VNOS-C. Additionally, data were supported with interviews at the end of the semester. Eight participants were interviewed with questions derived from the VNOS-C.

The Context of the Current Study

Participants from both two groups were engaged in different NOS activities (e.g. black box, tricky tracks) that explicit reflective approach to improve their views through one school semester. According to this, VNOS-C was used as a pre-test to determine participants' initial views of theories and laws, and it was also administered at the end of the semester as a post test to determine changes in participants' views. Semi-structured interview was undertaken with 8 participants as post tests in order to help uncover the participants' views.

This study was carried out with the analysis of three questions which are related with theories and laws. In these questions, the students are asked to define theory and law, expected to give examples related with them, expected to describe how theories and laws are constituted and asked whether there is a relationship between them. Each of the participants' pre and post survey' responses were analyzed by a coding system which has three-category coding scheme "naïve", "have merit" and "informed". Chi-square statistic indicated statistically significant differences from pre- to post-test responses of teachers' views. Also, the examples of theories and laws were analyzed given at the pre-test and post test.

3. RESULTS

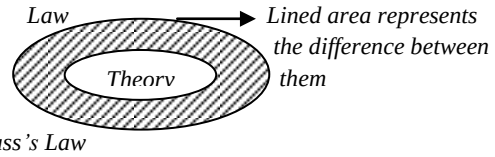
Generally, analysis of responses from pre-test and post-test indicated significant changes about theories and laws at the end of the semester. According to results of the analyses, it is established that 81.2% of pre-service science teachers (PST) and 81.4% of pre-service mathematic teachers (PMT) have 'naïve' view. The rest of the participants' (18.8% of PST and 18.6% of PMT) responses coded as 'have merit'. The most important result of this analyses is from both of the groups were not have responses about theories and laws coded as 'informed'. These results were constituted from the pre-service teachers' statements which defend that there is a hierarchical construct between theory and law. According to the responses of pre-test Chi-square analyses, statistically meaningful results were not obtained $\left[x^2_{(1)} = 0{,}000,\ p = 0.987\right]$. The pre-service teachers from both groups gave theory and law examples generally about physics, chemistry and biology. There are some examples given below about PST's and PMT's pre-test views.

S(5): Scientific theory, is the version of the result which is not exactly turning into a law obtained from our experiments. Atomic theory.

(M25): A scientific reality (hypothesis) becomes scientific theory if it gains validity about 90 % from the authorities. Relativity theory.

After the instruction the survey results were analyzed 3.1% of PST, and 34.9% of PMT have 'naive' views according to the post-test results. Beside this, 15.6% of PST and 34.9% of PMT have 'have merit' views after the instruction. Also, none of the participants coded as 'informed' before the instruction according to the pre-test results; however, 52% of the participants coded as 'informed' after the instruction. Meanwhile, results indicated that PST's views (81.2%) were more informed than PMT's views (30.2%) about theories and laws. According to the responses of post-test Chi-square analyses, statistically meaningful results were obtained $\left[x^2_{(2)} = 20{,}409,\ p = 0.000\right]$. There is some examples given below about PST's and PMT's post-test views.

S(32): Laws are the descriptions of facts in nature and observed or perceived relations in nature, Gravity Law

(M5) 

Surprisingly, interview results contradicted with VNOS results that half of participants stated that laws were more certain than theories and theories can be law if they prove. After the instruction some participants gave example of theories and laws relevant with math.

4. CONCLUSIONS AND IMPLICATIONS

Contrast to Bell, et.al. (2003) [3] this study emphasizes that the explicit instructional approach is effective in promoting improved student views about theories and laws. This study's results show that as Trembaths' (1972) [9] study, researchers who manipulated certain aspects of the learning environment in their attempts to enhance teachers' NOS conceptions will be success. One of the primary aims of science education is to train scientifically literate individuals for a healthy and developing society. To achieve this, science and math teachers must become scientifically literate. Therefore, educating science and math teachers with a contemporary view of scientific knowledge should become an important issue in teacher education.

5. REFERENCES

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