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Perceptions of Teachers Toward Nature of Science (NOS) and Attitude toward Teaching Nature of Science (NOS)

Abstract

The present research aimed to study the perceptions of teachers towards the Nature of Science (NOS) and their attitude towards teaching about the Nature of Science (NOS). In the study all the participant teachers exclusively belonged to the different science disciplines of higher education level i.e. college and university teachers of Mizoram University, Aizawl, Mizoram for the academic year 2019. Sample comprised of randomly selected 50 teachers out of a total 145 population of science teachers. The perceptions of participants towards NOS and their attitude towards teaching NOS were measured through VOSE (Views on Science and Education) questionnaire. On an average teachers held good perception toward NOS and a positive attitude toward teaching about NOS to their students. It was also found that the teachers' perception on NOS differed significantly about their discipline of practice. This result was supported using Student 't' test and one- way ANOVA analysis. However, teachers' perception on NOS did not differ significantly with regard to their teaching experience and gender. Similarly, teachers' attitude toward teaching NOS did not differ significantly with regard to their discipline of practice, teaching experience and gender.
Keywords: *Nature of Science (NOS), Perceptions of Teachers towards NOS, Attitude toward Teaching NOS*

Introduction

Research indicates that the concept of Nature of Science (NOS) is very vague among the students, teachers, researchers and the general public. Bell (2008) rightly puts it as the way of knowing / doing science which has a strong philosophical, historical and socio-cultural basis which is not understood through traditional school science. NOS is defined as the value and assumptions inherent to science and a science teacher must understand it to teach it (Lederman, 1992). There are three domains of science to be explored inside and outside science classroom experiences (Bell, 2008). The first domain refers to the huge, dynamic and ever-expanding body of knowledge which can be only glimpsed and showcased in limitations of school science. Often the inclusion and deletion of content in science courses is subject to some vested interest of major stake holders of school education which we are not discussing here. The second domain indicates the importance of practical experiences, the laboratory culture of school science wherein students learns methodology of doing science, the wave of hands on action popularized after the American progressive movement. Finally, the third domain relates to the NOS which is still an unfamiliar and alien domain in the Indian scenario. Often it is misunderstood by the teachers and mis-communicated to the students leading to conceptual stigmas. This domain of science is poorly addressed in majority of curricular materials, and when it is addressed it is misrepresented (Bell, 2008). Right understanding of NOS has a possibility of erasing misconceptions in science and its benefits can be had by establishing connections between the three domains which is solely the responsibility of science teachers and educators who need to redefine pedagogical approaches for the same. Abrahams (2009) suggests that research indicates of the affective component in doing science,the second domain of science as described by Bell (2008). Contradicting this, school science portrays a very insensitive image of world of science and people associated with the discipline. School science has been failing consistently to involve learner's affect into science learning which resulted into amplified state of science anxiety. NOS can be taught right from elementary years by linking it to essential process skills of science which is its' second domain (Bell, 2008). But things in reality quite contradict the real requirements of teaching and learning science. NOS is often addressed apart from real science contexts and methods and hence it becomes difficult to teach science teachers to understand and implement the nature of science instruction (Sumranwanich & Yuenyong, 2013). Student community find difficulty in understanding the real nature of science as it is the most compromised aspect of science curricula and they fall trap to the limitations of science curriculum (Bell, 2008).

The scientific community which is involved in knowledge generation endeavours is also not free from this misconception at large; however, exceptions are also equally available. The researchers in the field of science seem to be often disconnected with this philosophical underpinning associated with doing science and might consider themselves free from the responsibility of passing on the various dimensions of NOS to the larger masses. Knowingly or unknowingly NOS happens to be in a compromised state when it comes to knowledge dissemination expeditions which are largely governed by economic and political nature of the prevailing circumstances. The general public at large is the most ignorant category amongst all about the conceptions of NOS. However, they hold a very high expectation from science as a whole being very ignorant about the limits of science. According to Nott and Wellington (1993) there are some interesting dimensions to the NOS which are relativism vs. positivism, inductivism vs. deductivism, contextualism vs. decontextualism, process vs. content and instrumentalism vs. realism. Different people may associate themselves on these continuums in a varying way all of which are influenced by their training and practice of this discipline. Differences prevail both within and outside the scientific communities.

By knowing teacher's perception of science and its nature there can be a possibility to understand the readiness of teachers for NOS, a much debatable concept with regard to its clarity amongst the academicians. There has been no such study done in this field of science education especially in context of Mizoram. As a result, the investigators have decided to take up this task to fill in the gap in understanding the status of science education through the lens of teachers' understanding of NOS. Their perception holds a key to understand the missing links responsible for consistent underachievement of students in science. Looking into teachers' lens of NOS might help the investigators to uncover the hidden mis-concepts dwelling in their minds, who happen to be the major change makers in the lives of their students. The finding of the study is expected to reveal the status of perception of nature of science among science teachers at higher education level and hopefully provide further information for strengthening and improvement of science education. Although for decades the understanding of NOS has been listed as one of the major objectives in science education (Shulman & Tamir, 1973; Chen, 2006a), it has not yet been adequately emphasized in current educational practice. The recent reforms in science education specifically asks for including components of NOS as part of school science curriculum (AAAS, 1998; House of Commons Science & Technology Committee, 2002; McComas & Olson, 1998; Burton, 2012). Science education has accepted areas of NOS that are important for school-age students i.e. to understand that scientific knowledge is empirically based; both reliable and tentative; is the product of observation and inference, creative thinking; is subjective, to a degree; scientific laws and theories are different kinds of knowledge and not same, laws are not infallible but they can withstand the vigour of time and scientists use many methods to develop knowledge and not just scientific method (Burton, 2012).

Having said this the investigators are deeply interested to find answers to the following research questions exclusively targeting the science teaching community at tertiary level of education:

Research Questions

1. What is the perception of science teachers at tertiary level of education towards Nature of Science (NOS)?
2. Is there any difference among teachers' perceptions of Nature of Science (NOS) with regard to their teaching experience in science?
3. Does teachers' discipline of practice have any influence on their perceptions, thoughts and views of Nature of Science (NOS)?
4. Does gender play any role in development of nature of science (NOS)?

With the aim of finding valid answers to the above mentioned research questions, five research objectives were formulated mentioned in the analysis section.

Methodology

The purpose of the present study is to find out the perceptions of teachers towards NOS who are teaching at the tertiary level of education in various science disciplines of Mizoram University and all the colleges affiliated to Mizoram University which are offering courses in science.

Participants: The participants of the study are the teachers belonging to the major seven disciplines of Physics, Chemistry, Botany, Zoology, Biotechnology, Geology and Environmental Science who were serving in Mizoram University, Aizawl and all the colleges affiliated to Mizoram University which are offering courses in science.

Tool: In order to study the teachers' perception towards NOS and attitude towards teaching NOS, Views on Science and Education (VOSE) Questionnaire developed by Chen (2006a) is used. Chen (2006a) developed the VOSE questionnaire standardized on Chinese population. The purpose of study was to develop a valid, meaningful, and practical instrument for creating in-depth profiles of the views of college students or policy makers in science education, parents, community members, industry representatives, educators, content experts including pre-/ in-service teachers, about the nature of science (NOS), and NOS instruction (Chen, 2006a).VOSE has been found to be better in detecting the perceptions or interpretations of the items over the traditional instruments such as VOSTS (Chen, 2006a). VOSE focuses on seven aspects of NOS that are particularly relevant to K-12 science education which are i) Tentativeness of scientific knowledge;, ii) Nature of observation; iii) Scientific methods; iv) Hypotheses, laws and theories; v) Imagination; vi)validation of scientific knowledge; and vii) objectivity and subjectivity in science. In addition to questions about these seven aspects of NOS, VOSE includes five questions to examine the teaching attitudes corresponding to five of the NOS topics: teaching about the tentativeness of scientific knowledge, the nature of observation, the scientific method, the relationship between theories and laws, and the subjectivity embedded in science(Chen, 2006a). Due permission was sought from the questionnaire constructor of VOSE which has been tried on various populations of students and teachers and is found to be a culture fair questionnaire as the philosophical stance dealt in it can be considered to be universal.

Reliability and Validity of VOSE: The VOSE yields reliable results because the items originated from the respondents' viewpoints instead of experts' presumptions of reasonable responses. The test-retest reliability also is high, correlation coefficient, 0.82. The Cronbach's alphas of all issues of NOS in VOSE ranged from 0.34 to 0.81 (Chen, 2006a). For validity, the content and interpretation of the items were validated by two panels of experts, each consisting of six experts (Chen, 2006b)

Data Collection: The data was collected from randomly selected 50 teachers from the tertiary level of education working in Mizoram University and affiliated colleges of the Mizoram University, Aizawl, Mizoram. The total population comprised of 145 teachers for the academic session 2019 obtained from the institutes' websites.

Scoring Technique: As explained by Chen (2006b), VOSE comprise of 15 broad items under each of which are different number of responses against which choice of positions has to be made by the participants. VOSE assess both the subjects' conceptions of NOS and attitudes toward teaching NOS, as well as their underlying reasons. The conception and attitude parts consist of 10 and 5 questions (item 10, 11, 12, 13, & 14) respectively. Each question is followed by several items that represent different philosophical positions. The item is symbolized by a numerical number, indicating the question, and a letter, indicating the response for the question. For e.g. 1A stands for question 1 and letter A indicates one response for the item question. Participants are instructed to read all items of a question before ranking each on the five-point scale. The scores go from 0 to 4 which correspond for positions strongly disagree (SD), disagree(D), uncertain(U), agree(A) and strongly agree (SA). For data coding 16 items are to be regarded as naïve conceptions and their scores are to be reversed which are 9A, 9B, 9F,7A ,7B, 3C, 3D,3E,2C, 2D, 15F, 8C, 15E, 15I,8C and 8D.

Findings and Interpretations

A. Quantitative Findings

Objective 1: To find out the perceptions of higher education science teachers towards Nature of Science (NOS).

Since VOSE gives scores separately on conceptions of NOS and Attitude for Teaching NOS, the interpretations were recorded separately.

a) Teachers' conceptions of NOS

Teachers were found to obtain a mean score of 120.04 with a maximum and minimum score of 151 and 67 corresponding to the item nos. 1-9 and item 15.The scores for the different issues of NOS conception were also calculated to find out the teachers' conceptions of NOS. Mean scores on each of the NOS issues as provided by Chen (2006a) were calculated which are presented in Table 1.

Table 1: Results of the Views on Science and Education: Philosophical Stances

NOS Issues	Mean	SD	SEM	Minimum	Maximum
Tentativeness	2.8	0.74	0.104	0	4
Nature of Observation	1.94	0.46	0.06	0.8	2.8
Scientific Methods	1.69	0.46	0.064	0.7	2.7
Theories	2.52	0.58	0.081	0.5	3.7
Laws	2.59	0.49	0.068	1.6	3.8
Comparison between theories and laws	1.61	0.48	0.07	0.5	2.75
Use of Imagination	2.52	0.71	0.101	0.6	4
Validation of Scientific Knowledge	1.59	0.78	0.109	0	3.3
Subjectivity	2.54	0.49	0.069	0.9	3.3
Objectivity	1.98	0.27	0.037	1.4	2.5

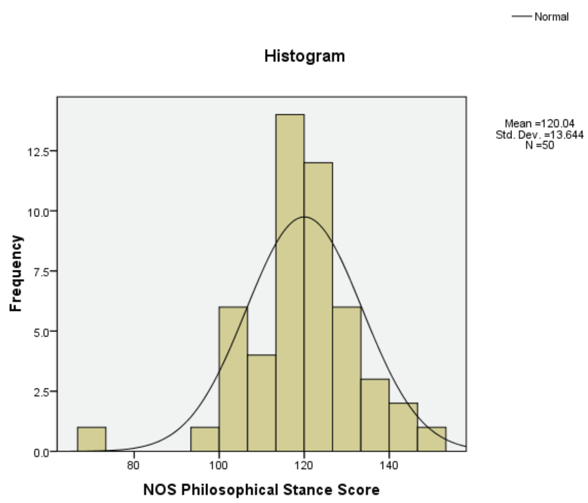

Fig 1: Normal Distribution Curve for Teachers' scores on NOS Philosophical Stance

Table 1 provides the description of the distribution of teachers' philosophical stance regarding all the NOS issues as described by Chen (2006a). The maximum possible score for these 10 items was 55 × 4 = 220. The responses followed a normal distribution (Fig 1). Table 1 shows that maximum mean score of (2.8/4) was obtained for the philosophical stance of 'tentativeness' and minimum mean score of (1.59/4) was obtained for the philosophical stance of 'validation of scientific knowledge'.

b) Attitude toward teaching NOS

The total scores for teachers' attitude were separately calculated to find out the teachers' attitude towards teaching NOS topics to their students. Teachers were found to obtain a mean score of 72 with a maximum and minimum score of 90 and 32 corresponding to item No. 10-14.

The total scores for the different issues of attitude for teaching NOS were also calculated to find out the teachers' attitude for teaching NOS. Mean scores on each of the NOS issues as provided by Chen (2006a) were calculated which are presented in Table 2.

Table 2: Results of the views on Science and Education: Attitudes toward teaching NOS

NOS Topic	Mean	SD	SEM	Minimum	Maximum
Tentativeness	2.03	0.54	0.075	0.8	3.2
Nature of Observation	2.22	0.54	0.076	0.6	3.2
Scientific Methods	2.59	0.48	0.068	0.33	3.55
Theories and Laws	2.21	0.49	0.068	0.75	3.25
Subjectivity and Objectivity	2.66	0.49	0.068	2	3.86

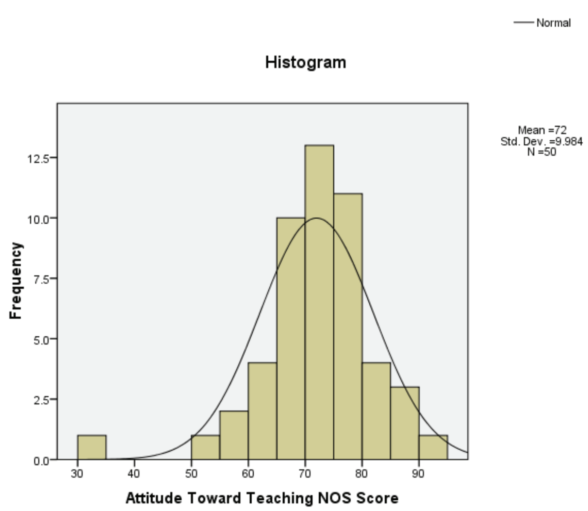

Fig 2: Normal Distribution Curve for Teachers' scores on Attitude toward Teaching NOS

Table 2 provides the description of the distribution of teachers' attitude toward teaching NOS for various issues as described by Chen (2006a). The maximum possible score for these 5 items was 30 × 4 = 120. The responses followed a normal distribution (Fig 2). Table 2 shows that maximum mean score of (2.7/4) was obtained for the philosophical stance of 'subjectivity and objectivity' and minimum mean score of (2.03/4) was obtained for the philosophical stance of 'tentativeness'.

Objective 2: To examine and compare higher education science teacher's perceptions of nature of science (NOS) with respect to their discipline of practice.

For the present study data was collected from teachers belonging to seven streams of science which are Botany, Bio-Technology, Chemistry, Environmental Science, Geology, Physics and Zoology,. For the purpose of comparison of teachers' perception of NOS, the teachers were divided into two groups broadly, one belonging to discipline of Physical Science comprising of teachers from Physics, Chemistry and Geology streams. The other group formed the Biological Science group comprising of teachers from Botany, Biotechnology, Environmental Science and Zoology stream. Table 3 provides the numbers of teachers from each stream with respect to their gender and teaching experiences.

Table 3: Sample Teachers in different Streams of Science

Science Streams	Number of Teachers			
	Male	Female	More than 10 years of Teaching Experience	Less than 10 years of Teaching Experience
Botany	3	3	3	3
Biotechnology	5	1	3	3
Chemistry	3	4	4	3
Environmental Science	3	6	4	5
Geology	4	3	2	5
Physics	2	0	2	0
Zoology	5	8	7	6
TOTAL	25	25	25	25

With reference to Table 3, the Physical Science and Biological Science group comprised of 16 and 34 teachers respectively.

The comparison was separately done for two important aspects of VOSE viz.

a) To examine and compare higher education science teacher's conceptions of nature of science with respect to their discipline of practice.

b) To examine and compare higher education science teacher's attitude towards teaching of nature of science with respect to their discipline of practice.

a) In order to compare teachers' conceptions of NOS, statistical test of student 't' test for unpaired sample assuming equal variances was performed by calculating the F-ratio between the higher and lower variance of the two samples as the F statistics (1.83) < F critical(2.31, α=0.025 for 2-tailed test) for df (15,33).

The research objective guided to propose the following null hypotheses:

$H_0$2 a: *There is no significant difference in teacher' conceptions of NOS working at tertiary level with respect to their discipline of practice.*

H_0: $\mu_1 = \mu_2$ where μ_1= Physical Science Teachers' mean score on NOS stance & μ_2 = Biological Science Teachers' mean score on NOS stance. Table 4 depicts the t-test analysis

Table 4: Significance of Difference between Teachers' conceptions of NOS in relation to their discipline of practice

Nature of Science Discipline	Number	Mean	S.D.	SEM	t value	Df	P value	Significance of Difference	Decision on Null Hypothesis
Physical Science	16	126.88	10.31	2.58	2.57	48	0.013	S*	Rejected
Biological Science	34	116.82	13.96	2.39					

Source: Field data. *The test suggests that the difference between the two means is significant at 0.05 level.

Interpretation: A reference to Table 4 reveals that the obtained t value (2.57) was found significant at 0.05 level with degrees of freedom 48, 't' critical value (2.01) for 2 tailed analysis being < obtained 't' value. It means that teachers' conception of NOS differ significantly with respect to their discipline of practice. Hence the null hypothesis is rejected. It was found that group of Physical Science teachers have better conceptions of NOS than the Biological Science group with a mean difference of 10.06. Further standard deviation is higher in biological science group.

Further an attempt was made to perform one-way ANOVA statistics by segregating the samples into 3 groups which are Physical Science (Physics, Chemistry, Geology), Inter-disciplinary Science (Bio-Technology and Environmental Science) and Biological Science (Botany and Zoology) having 16, 15 and 19 teachers in these groups respectively. Table 5 shows the obtained F-value.

A reference to Table 5 reveals that the obtained F value, 3.20 was found significant at 0.05 with degrees of freedom 2 for numerator (df1) and 47 for denominator (df2), F critical value (3.20) being ≤ obtained F ratio. It means that teachers' conception of NOS differs significantly with respect to their discipline of practice. Hence the null hypothesis is rejected.

Table 5: F value in relation to Conception of NOS of Physical Science, Interdisciplinary Science and Biological Science Teachers

Source of Variance	Df	Sum of Squares (SS)	Mean Square (Variance)	F Ratio	F critical	P value	Level of Signifi-cance	Decision on Null Hy-pothesis
(Treatments) Between Groups	2	1455.5	727.74	(MS treat-ment/MS residual) 4.462	3.20	0.017	0.05	Rejected
(Residuals)Within Groups	47	7666.4	163.12					
Total	49	9121.9						

Since here F-test is only providing an overall result that there is a statistically significant difference between the given group means but it does out finds out which group is different from other group. A Post-Hoc test of Multiple Comparison Test was performed since the P value is less than 0.05. Since the sample sizes are unequal, the Tukey-Kramer test was performed to determine which pair-wise comparisons are significant. Table 6 provides the results of the test.

Table 6: Tukey-Kramer Multiple Comparison Test

Groups	Count	Mean	Comparison	Mean Difference	Q	P value
Physical Science	16	126.88	Inter-disciplinary Science vs. Biological Science	6.52	2.090	NS P>0.05
Inter-disciplinary Science	15	120.47	Inter-disciplinary Science vs. Physical Science	-6.41	1.974	NS P> 0.05
Biological Science	19	113.95	Biological Science vs. Physical Science	-12.93	4.219	S* P<0.05

The Tukey-Kramer Test indicated that the only significant comparison is that of Biological Science - Physical Science group revealing existence of significant difference with regard to the their conception of NOS at 0.05 level of significance. The conceptions of NOS in the physical science group are found to be better over the biological science

b) In order to compare teachers' teacher's attitude towards teaching of NOS, statistical test of student 't' test for unpaired sample assuming equal variances was performed by calculating the F-ratio between the higher and lower variance of the two samples as (1.82) < F critical(2.64, α=0.025 for 2-tailed test) for df (15,33).

The research objective guided to propose the following null hypotheses:

$H_0$2 b: *There is no significant difference in teachers' attitude towards teaching NOS working at tertiary level with respect to their discipline of practice.*

H_0: $\mu_1 = \mu_2$ where μ_1 = Physical Science Teachers' mean score on Attitude toward teaching NOS & μ_2 = Biological Science Teachers' mean score on Attitude toward teaching NOS. Table 7 depicts the t-test analysis.

Table 7: Significance of Difference between Teachers' Attitude towards teaching NOS in relation to their discipline of practice

Nature of Science Discipline	Number	Mean	S.D.	SEM	t value	Df	P value	Significance of Difference	Decision on Null Hypothesis
Physical Science	16	71.63	8.05	2.01	0.18	48	0.857	NS	Accepted
Biological Science	34	72.18	10.88	1.87					

Source: Field data. The test suggests that the difference between the two means is not significant at 0.05 level.

Interpretation: A reference to Table 7 reveals that the obtained t value (0.18) was not found significant at 0.05 level with degrees of freedom 48, 't' critical value (2.01) for 2 tailed analysis being > obtained 't' value. It means that teachers' attitude towards teaching NOS do not differ significantly with respect to their discipline of practice. Hence the null hypothesis is accepted

Further an attempt was made to perform one-way ANOVA statistics by segregating the samples into 3 groups which are Physical Science (Physics, Chemistry, Geology), Inter-disciplinary Science (Bio-Technology and Environmental Science) and Biological Science (Botany and Zoology) having 16, 15 and 19 teachers in these groups respectively. Table-21 shows the obtained F-value.

Table 8: F value in relation to Teachers' Attitude towards teaching NOS of Physical Science, Interdisciplinary Science and Biological Science Teachers

Source of Variance	Df	Sum of Squares (SS)	Mean Square (Variance)	F Ratio	F critical	P value	Level of Significance	Decision on Null Hypothesis
(Treatments) Between Groups	2	8.124	4.062	(MS treatment/MS residual) 0.039	3.20	0.96	0.05	Accepted
(Residuals) Within Groups	47	4875.9	103.74					
Total	49	4884.0						

A reference to Table 8 reveals that the obtained F value, 3.20 was found not significant at 0.05 with degrees of freedom 2 for numerator (df1) and 47 for denominator (df2), F critical value (3.20) being > obtained F ratio. It means that, those teachers' attitude towards teaching NOS do not differ significantly with respect to their discipline of practice. Hence the null hypothesis is accepted. Post tests were not calculated because the P value was greater than 0.05.

Objective 3: To examine and compare higher education science teacher's perceptions of nature of science (NOS) with respect to their teaching experiences.

For the above objective of study, the sample was divided into two groups. With reference to Table 3 the sample comprised of 25 teachers having more than ten years of teaching experience and 25 teachers having less than ten years of teaching experience. The comparison was separately done for two important aspects of VOSE viz.

a) To examine and compare higher education science teacher's conceptions of nature of science with respect to their teaching experiences.
b) To examine and compare higher education science teacher's attitude towards teaching of nature of science with respect to their teaching experiences.

a) In order to compare teachers' conceptions of NOS, statistical test of students' 't' test for unpaired sample assuming equal variances was performed by calculating the F-ratio between the higher and lower variance of the two samples as the F statistics (2.26) ≤ F critical (2.26, α=0.025 for 2-tailed test) for df (24,24).

The research objective guided to propose the following null hypotheses:

H_0 3a: *There is no significant difference in teacher' conceptions of NOS working at tertiary* level with respect to their teaching experiences

H_0: $\mu_1 = \mu_2$ where μ_1 = Mean score on NOS stance of teachers having more than 10 years of teaching experience & μ_2 = Mean score on NOS stance teachers having less than 10 years of teaching experience. Table 9 depicts the t-test analysis.

Table 9: Significance of Difference between Teachers' conceptions of NOS in relation to their teaching experiences

Teaching Experience	Number	Mean	S.D.	SEM	t value	Df	P value	Significance of Difference	Decision on Null Hypothesis
More than 10 years	25	119.59	16.22	3.25	0.25	48	0.80	NS	Accepted
Less than 10 years	25	120.52	10.79	2.16					

Source: Field data. The test suggests that the difference between the two means is not significant at 0.05 level.

Interpretation: A reference to Table 9 reveals that the obtained t value (0.25) was not found significant at 0.05 level with degrees of freedom 42, 't' critical value (2.01) for 2 tailed analysis being > obtained 't' value. It means that teachers' conception of NOS do not differ significantly with respect to their teaching experience. Hence the null hypothesis is accepted.

a) In order to compare teacher's attitude towards teaching of NOS, statistical test of students' 't' test for unpaired sample assuming equal variances was performed by calculating the F-ratio between the higher and lower variance of the two samples as the F statistics (2.24) <F critical (2.26, α=0.025 for 2-tailed test) for df (24,24).

The research objective guided to propose the following null hypotheses:

H_0 3 b: *There is no significant difference in teachers' attitude towards teaching NOS* working at tertiary level with respect to their teaching experiences

H_0: $\mu_1 = \mu_2$ where μ_1 = Mean score on Attitude toward teaching NOS of Teachers having more than 10 years of teaching experience & μ_2 = Mean score on Attitude toward teaching NOS of teachers with less than 10 years of teaching experience. Table 10 depicts the t-test analysis.

Table 10: Significance of Difference between Teachers' Attitude towards teaching NOS in relation to their teaching experiences

Gender	Number	Mean	S.D.	SEM	t value	Df	P value	Significance of Difference	Decision on Null Hypothesis
Male Teachers	25	72.76	11.83	2.34	0.53	48	0.59	NS	Accepted
Female Teachers	25	71.24	7.89	1.58					

Source: Field data. The test suggests that the difference between the two means is not significant at 0.05 level.

Interpretation: A reference to Table 10 reveals that the obtained t value (0.53) was not found significant at 0.05 level with degrees of freedom 48, ', 't' critical value (2.01) for 2 tailed analysis being > obtained 't' value. It means that teachers' attitude towards teaching NOS do not differ significantly with respect to their teaching experience. Hence the null hypothesis is accepted.

Objective 4: To examine and compare higher education science teacher's perceptions of nature of science (NOS) with respect to their gender.

With reference to Table 3 the sample comprises of 25 male and 25 female teachers. The comparison was separately done for two important aspects of VOSE viz.

a) To examine and compare higher education science teachers conceptions of nature of science with respect to their gender

b) To examine and compare higher education science teacher's attitude towards teaching of nature of science with respect to their gender.

a) In order to compare teachers' conceptions of NOS, statistical test of students ' 't' test for unpaired sample assuming equal variances was performed by calculating the F-ratio between the higher and lower variance of the two samples as the F statistics (0.53) < F critical(2.26, α=0.025 for 2-tailed test) for df (24,24).

The research objective guided to propose the following null hypotheses:

$H_0$4 a: *There is no significant difference in teachers' conceptions of NOS working at* Tertiary level with respect to their gender

H_0: $\mu_1 = \mu_2$ where μ_1 = Mean score on NOS stance of Male Teachers & μ_2 = Mean score on NOS stance of Female teachers. Table 11depicts the t-test analysis.

Table 11: Significance of Difference between Teachers' conceptions of NOS in relation to their Gender

Group	Number	Mean	S.D.	SEM	t value	Df	P value	Significance of Difference	Decision on Null Hypothesis
Male Teachers	25	121.24	11.49	2.29	0.62	48	0.54	NS	Accepted
Female Teachers	25	118.84	15.65	3.13					

Source: Field data. The test suggests that the difference between the two means is not significant at 0.05 level.

Interpretation: A reference to Table 11 reveals that the obtained t value (0.62) was not found significant at 0.05 level with degrees of freedom 48, 't' critical value (2.01) for 2 tailed analysis being > obtained 't' value. It means that teachers' conception of NOS do not differ significantly with respect to their gender. Hence the null hypothesis is accepted.

b) In order to compare teachers' teacher's attitude towards teaching of NOS, statistical test of students' 't' test for unpaired sample assuming equal variances was performed by calculating the F-ratio between the higher and lower variance of the two samples as the F statistics (0.37) < F critical (2.26, α=0.025 for 2-tailed test) for df (24,24).

The research objective guided to propose the following null hypotheses:

$H_0$4 b: *There is no significant difference in teachers' attitude towards teaching NOS* working at tertiary level with respect to their gender

H_0: $\mu_1 = \mu_2$ where μ_1 = Mean score on Attitude toward teaching NOS of Male Teachers & μ_2 = Mean score on Attitude toward teaching NOS of Female Teachers. Table 12 depicts the t-test analysis.

Table 12: Significance of Difference between Teachers' Attitude towards teaching NOS in relation to their Gender

Group	Number	Mean	S.D.	SEM	t value	Df	P value	Significance of Difference	Decision on Null Hypoth-esis
Male Teachers	25	73.72	7.34	1.47	1.22	48	0.23	NS	Accepted
Female Teachers	25	70.28	11.97	2.39					

Source: Field data. The test suggests that the difference between the two means is not significant at 0.05 level.

Interpretation: A reference to Table 12 reveals that the obtained t value (1.22) was not found significant at 0.05 level with degrees of freedom 48, 't' critical value(2.01) for 2 tailed analysis being > obtained 't' value.. It means that teachers' attitude towards teaching NOS do not differ significantly with respect to their gender. Hence the null hypothesis is accepted.

Qualitative Findings

Objective 5: To qualitatively analyze the higher education science teacher's view on Nature of Science (NOS).

The obtained data was also subjected to qualitative analysis for certain philosophical stance as explained by Chen (2006a). Chen (2006a) reports that the issue of the tentativeness of scientific knowledge could incorporate three phases in its development: revolutionary where knowledge and the way science is practiced are dramatically changed (Kuhn, 1970), cumulative where knowledge is accumulated in the period of scientific paradigm and evolutionary where the change is relatively minor, and a theory may be refined to incorporate new evidence (Popper, 1975/1998). Studies have indicated that teachers may not take a specific philosophical stance and may even go with each of it (Gallagher, 1991; Koulaidis & Ogborn, 1989) and may change their philosophical stance when teaching in different contexts (Hodson, 1993). Considering this special issue the responses for this question were qualitatively analyzed. With regard to the distribution of teachers' stance on 'tentativeness of scientific knowledge' it is found that maximum participants (62%) agreed that scientific research will face revolutionary change, and the old theory will be replaced going for evolutionary stance about the tentativeness of scientific knowledge however 20 participants disagreed to the notion and 18 could not decide. Majority (74%) agreed that scientific advances cannot be made in a short time but is a cumulative process preserving the old theories and scientists will accept different theories as both are shaded by different perspectives. Around 10 participants disagreed to the notion and 16 could not decide. Lastly maximum participants (76%) agreed with the evolutionary nature of scientific knowledge favouring the notion that with the accumulation of research data and information, the theory will evolve more accurately and completely, not being disproved. 8 participants did not favour the notion and 16 participants could not decide. The analysis suggests that their conceptions are not stable and are sometimes contradictory supporting the earlier studies (Abd-El-Khalick & BouJaoude, 1997; Mellado, 1997).

Another issue which may suggest an opposing and contradicting stance is that concerning the epistemological status of theories and laws. According to Chen (2006b) scientists create theories and laws to interpret and describe empirical evidence; however, some may argue that both are invented whereas other believes they discover them presuming a single objective reality. The nature of science constitutes a domain of science which is by far the most abstract and least familiar (Bell, 2008). In science, a law is a succinct description of relationships or patterns in nature consistently observed in nature. On one hand, laws are often expressed in mathematical terms and a scientific theory is a well-supported explanation of natural phenomena. Thus, theories and laws constitute two distinct types of knowledge. One can never change into the other. On the other hand, they are similar in that they both have substantial supporting evidence and are widely accepted by scientists. Either can change in light of new evidence (Bell, 2008). The nature of science strictly differentiates between laws and theories explaining evidence with different purposes and is incomparable. The questionnaire also addressed this issue and it is found that maximum participants (68%) and (76%) agreed that a theory is discovered, many participants also held the notion (70%) that theories are either discovered or invented and some participants (66%), (54%) and (42%) agreed that theories are invented as a result of scientific experimentation and can be later disproved. It is found maximum participants (88%) believe that laws are discovered as they are already out there, more than half (68%) believe that laws are discovered based on experimental facts. A similar percentage (68%) felt that laws are sometimes accidentally discovered and sometimes invented. Rest 50% and 42% felt scientific laws are invented after interpreting experimental facts and due to lack of absolutes in nature respectively. However, 40% of participants could not decide for lack of absolutes. Participants views in comparison of laws and theories it was found maximally 78% and 84% participants agreed that theory are not stable as laws and a theory which stands many tests will eventually become law. On the contrary 46% participants agreed that some theories have more supporting evidence than some laws and only 32% participants agreed that theory and laws are different types of ideas which cannot be compared. Almost all of participants (94%) had a positive attitude towards teaching the relationship between hypothesis, theory and law to high school students as they represent the structure of scientific knowledge. Majority of participants (82%) agreed that they represent the fundamental of scientific inquiry and should be taught. However, only 18% and 22% participants agreed that teaching the relationship does not help students to understand the NOS and does not communicate definite meaning respectively.

Further another issue was analyzed based on subjectivity and objectivity in science. Scientific knowledge is mostly empirically based and scientists try to be open-minded and apply mechanisms such as peer review and data triangulation to improve objectivity however, personal beliefs, values, intuition, judgment, creativity, opportunity, and psychology all play a role in scientific activities (Chen, 2006a). It is therefore not wrong to say that there is an influence of the society, culture, background of scientists and discipline in which they are embedded or educated which is reflected in their observations, interpretations, use of imagination, and theory choice as subjectivity (Chen, 2006a). Science as a human enterprise is practiced in the context of a larger culture and its practitioners (scientists) are the product of that culture (Lederman et al, 2002). The present study indicated that tertiary level teachers generally felt that socio-cultural background of scientists and their cultural imprints may influence them and their scientific investigations, however their stance is not clearly on one side as they agreed to notions that scientific inquiries should be free from subjective inclinations but equally participants disagreed on the notion. Moreover, they believed that it is important to consider both scientific research and social values simultaneously and their interactions should be made known to secondary school students and it is inevitable to escape from keeping the two views in isolation i.e. the subjective and objective views. On the whole participants agree that rationality is key behind doing science and shouldn't not be compromised on grounds of subjectivism. This finding is in agreement with another similar study (Burton, 2012). With regard to distribution of teachers' stance 'scientific investigations are influenced by socio-cultural values (e.g., current trends, values)' against various responses, it is found that almost 70% participants agreed that socio-cultural values influence the direction and topics of scientific investigations and almost 60% of them agreed that scientific investigations are influenced by socio-cultural values. However, around 48% participants agreed that scientists always ought to remain value-free when carrying out research. Many participants (58%) believed that objectivity and subjectivity are contrary to each other and in science objectivity overrules subjectivity.

Discussion

The results of the present study are encouraging as teachers of tertiary level do possess moderately fair ideas on NOS philosophical stance, however few teachers scored poorly but, on an average, their composite scores were satisfactory. They scored much better on possessing a positive attitude toward teaching the philosophical stance to their students. Based on the findings of this study, there is evidence that teachers do agree to opposing philosophical stances as well which they seem to gradually acquire by the virtue of their practice in the discipline and it has an impact on teachers' practice in teaching NOS. Triangulating both the quantitative and qualitative findings it is found that teachers at tertiary level do not differ in their philosophical positions of NOS especially with regard to their teaching experience and gender. It means even teachers with more teaching experience seem to except the popular notions about NOS such as discussed under the qualitative findings section. However the teachers from physical sciences (hard sciences) background seemed to have somewhat better understanding of the notion of NOS than the teachers belonging to biological sciences (soft sciences) which seem to encourage certain myths about NOS such as superiority of scientific method, subjectivity and objectivity in doing sciences and confusion between theories and laws. Qualitative findings further suggest that many teachers seem unable to choose their stance and reserved their responses as undecided. This indicates that the notion of NOS lacks uniformity on certain NOS issues, are more inclined to have common notion for few other issues. The present study is interesting as it is indicative of compromised state of real NOS in traditional science classroom and many misunderstandings continue to prevail. However, this study has a brighter side about teachers' attitude towards teaching NOS, teachers being more proactive toward their actions as teachers.

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