New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION

Maltese Post-Secondary Lecturers' Views on the Nature of Science

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Abstract

This study investigates the nature of science (NOS) views of Maltese, post-secondary lecturers. The research tools were the SUSSI questionnaire coupled with semi-structured interviews based on the VNOS-Form C questionnaire. A total of 252 questionnaires were collected and ten interviews were carried out. The outcome showed transitional to adequate views on five NOS components: the tentativeness of scientific theories, scientific methodology, the social/cultural aspect of science, the use of imagination and creativity, and the nature of observations and inferences with inadequate views regarding the distinction between laws and theories.

The NOS ideas of various subgroups were highly uniform per age group and lecturing experience. Gender yielded a statistically significant difference on the distinction between laws and theories. Comparing areas of specialisation, applied science lecturers had more naïve views on most NOS components, yielding statistically significant differences on imagination and creativity and changes in theories. Considering closest traditional area, lecturers with Physics as closest area exhibited more naïve views on both change of scientific theories and the social/cultural aspect. For NOS views per highest qualification, PhDs had significantly better views on change of scientific theories.

Keywords: NOS components, NOS views, post-secondary sector, lecturers

1. Introduction

Most countries advocate a proper understanding of the nature of science (NOS) as this is related to better scientific literacy [1] [7] [14]. A proper understanding of the NOS has been linked to better decision-making skills (especially on socio-scientific issues), improved science learning (mostly in particular topics as energy, electricity and magnetism) while aiding the co-existence of scientific and religious beliefs [19]. There is very little research targeting the NOS views of post-secondary lecturers [3] that influence the views of both future science teachers and scientists. This study aimed to investigate these views mainly through the following research question:

What are the NOS views of Maltese post-secondary lecturers?

The study compared the views of Maltese lecturers in pure science, applied science and the humanities. Ideas on the NOS were also compared by age bracket, years of experience, gender, traditional science area and highest qualification.

2. What is the NOS?

Contemporary literature shows that there are two major ideas regarding the term NOS. These are 'the general aspects view' [5] mostly popularised by Lederman, and the criticisms of such a view. In the 'general aspects view' several authors agree that despite differences between the ideas about NOS of specialists in the area – including scientists, philosophers, and science educators – such discrepancies should not be problematic at the secondary school level. Subsequently, a number of studies empirically identified several NOS tenets that are suitable for this level of generality. However, some authors criticise this view as it regards scientific inquiry [SI] as a separate construct from the NOS, thus giving a narrow perspective of the term while ignoring differences between scientific disciplines [4]. Other authors argue that these tenets may function as a mantra hindering

thoughtfulness and critical thinking [11] [15]. Despite such criticisms, the 'general aspects view' was adopted for this study as it incorporates the views investigated through the 'Student Understanding of Science and Scientific Inquiry' [SUSSI] questionnaire and the interview schedule used in this study. The 'general aspects view' incorporates these NOS aspects: observations and inferences; tentativeness; scientific theories and scientific laws; social and cultural embededness; creativity and imagination; and scientific methods.

3. Methodology

This study utilised a mixed-methods approach to investigate the NOS views of Maltese post-secondary lecturers. It combined quantitative and qualitative data using a convergent design [2] to gain a deeper understanding. The SUSSI questionnaire developed by Liang et al. [9] coupled with semi-structured interviews based on the Views on the Nature of Science [VNOS] -Form C questionnaire [6] were the two main study tools.

3.1 Data Collection

The SUSSI questionnaire was distributed to a total of 1403 lecturers teaching in various post-secondary institutions in Malta including the University of Malta (UOM), the Malta College of Arts Science and Technology (MCAST) and all the sixth form colleges. A total of 252 responses were collected, yielding a margin of error of 5.59% at a 95% confidence level. A convenient sampling strategy was used to recruit a total of ten interviewees from the various post-secondary institutions covering various disciplines.

3.2 Data Analysis

3.2.1 Questionnaire – closed questions

Data analysis combined responses from the questionnaire and semi-structured interviews. The SUSSI questionnaire consisted of 24, 5-point Likert-scale statements and six open questions. In each case, four statements and a corresponding open question assessed a given NOS tenet: a total of six NOS tenets were targeted in the questionnaire. The mean score for each participant on each NOS tenet was worked out and classified as an adequate, inadequate or transitional view of the NOS: the higher the mean score, the more adequate the resultant participant's view. Such analysis is similar to the one carried out by Miller et al. [13]. Further analysis was carried out for each individual Likert sub-scale, where a score of 1 or 2 was considered as an inadequate view, a score of 4 or 5 was considered as an adequate view while a score of 3 indicated an intermediate or transitional view. Percentages, frequency tables and bar graphs were utilised to illustrate these results for all participants. Normality tests, which yielded a skewed distribution on each NOS tenet, were then carried out. Subsequently, a non-parametric test - the Kruskal-Wallis test – was used to compare the views of participant lecturers within the various subgroups.

3.2.2 Questionnaire – open questions

Open-ended responses were analysed using the rubric developed by Liang et al. (2009) as cited in Miller et al. [13]. Each response was denoted by a score of 0 to 3. 1, 2 and 3 indicated an inadequate view, an intermediate view and an adequate view respectively. A score of 0 corresponded to no response, an incomplete response or an unclassifiable one. Considering the ordinal scale of both the Likert statements and the open questions, a frequency table coupled with the Kendall's tau-b test were used to find out if there is agreement between the open and close-ended responses of all participants.

3.2.3 Interviews

Interview responses were initially analysed by inductive coding and transcription codes were identified in the margins. These codes were then merged and linked into coding frames which were mainly hierarchical [12]. Subsequently, a set of emerging themes was identified. To merge the findings of the interviews further with those of the questionnaire, an overall analysis of each participant's views using the open questions' rubric was also carried out.

4. Results

4.1 Views of all participants

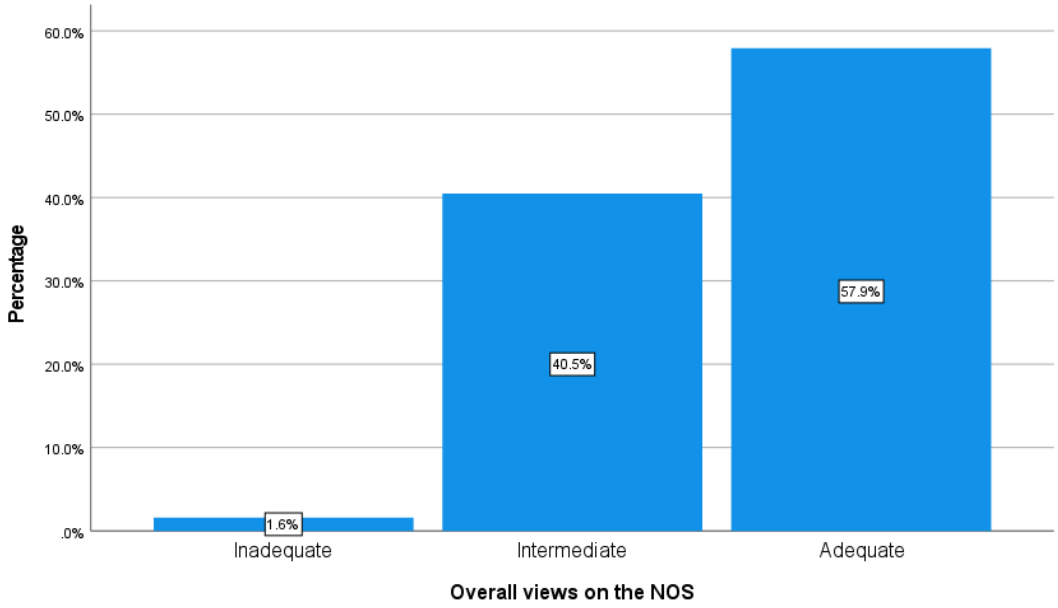

Figure 1: A bar graph showing the percentage of views based on the overall mean for the NOS

The overall mean score for all participants considering the whole questionnaire (Figure 1) showed that most Maltese post-secondary lecturers held adequate views on the NOS: 57.9% of participants exhibited adequate views, alongside 40.5% exhibiting intermediate views and 1.6% having inadequate views. Concomitantly, when looking at the mean score of each component, the highest percentage of adequate views was observed for the tentativeness of scientific theories (87.7%), followed by scientific methodology (73.0%), social and cultural influence on science (68.7%), imagination and creativity in scientific investigations (66.3%) and observations and inferences (62.7%). However, only 21.0% of participants showed adequate views on scientific laws vs. theories. Considering the open responses, a higher number of participants exhibited intermediate rather than adequate views. In many cases, this was attributable to incomplete, short answers or a stringent criterion when classifying the responses [8]. Generally, interview responses tended to support questionnaire findings as most participants expressed similar views to those found through the questionnaire.

4.2 Views of various subgroups

A high uniformity of views was found when comparing the views within the various subgroups. Age group and lecturing experience yielded no significant differences in any of the components, while gender only yielded a significant difference on laws vs. theories where males exhibited better views than females. However, such findings were not corroborated by qualitative interview data and hence were not considered conclusive.

Comparison by area of specialisation showed that applied science lecturers held more naive views than pure science and humanities lecturers on five NOS components, with significant differences on change of scientific theories and the use of imagination and creativity in science. This finding may be attributed to lack of prior reflection on the NOS [3] since applied science lecturers tend to focus more on the practical aspects of science rather than the epistemological underpinnings of the knowledge, thus potentially contributing to more naive NOS views.

When comparing the views by closest, traditional science area, lecturers whose closest traditional science area is Physics exhibited more naive views on four NOS tenets. However, these differences were only statistically significant in the case of change of scientific theories and the social and cultural influence on science. Such a finding is similar to that of other studies [16] [17] [18] and was attributed

to the mathematical basis of Physics which makes one perceive science as more absolute when compared to other disciplines [18].

Finally, NOS views were compared by highest qualification. Improvement on NOS views was observed on four NOS components, but this difference was only statistically significant on change of scientific theories. Lecturers with a PhD manifested more adequate NOS views with respect to those having a Masters or a Bachelors degree. Such a finding may be attributed to a greater exposure to research, its subsequent subjective nature and the philosophical aspect that comes in with the defence of one's doctoral thesis.

4. Conclusion

This study provided valuable insights on the NOS ideas of Maltese post-secondary lecturers. It showed that most Maltese lecturers exhibit adequate NOS views on most components with huge similarities among the different subgroups. This promising result indicates that the right initial steps have already been made and good ground was gained towards adequate NOS views and scientific literacy in Malta.

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