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What are Maltese Undergraduate Students' Views of the Nature of Science and Scientific Inquiry?

Rachel Pace, Josette Farrugia
University of Malta (Malta)
rachel.pace.10@um.edu.mt, josette.farrugia@um.edu.mt

Abstract

An understanding of the Nature of Science (NOS) and Scientific Inquiry (SI) is essential to acquire both scientific literacy and decision-making skills [1-6]. In the study reported in this paper, the Student Understanding of Science and Scientific Inquiry (SUSSI) questionnaire, developed by Liang, Chen, Chen, Kaya, Adams, Macklin, and Ebenezer [7] was used to investigate the NOS views held by 343 Maltese undergraduate students attending the University of Malta. The views of different sub-groups including science and non-science majors, science students in different years of study and gender were compared. Overall undergraduate students had inadequate to transitional views of the NOS. Students had transitional views on the objective and tentative NOS. Less adequate views were observed on the use of imagination and creativity in science, the social and cultural aspect of science and scientific methodology. Naïve views were in turn most common on the distinction between scientific laws and theories with most students perceiving scientific laws as being more certain than theories. Science students were more convinced than non-science students about their views on two aspects of the NOS, namely the nature of observations and inferences, whether these are subjective or objective, and the social/ cultural aspects of science. Science students also held better views than non-science students on the role of imagination and creativity in science. This may imply that science education positively affects their views on this component. Variation by gender and years of study was in turn minimal as students in different subgroups held very similar views. Based on these findings this study provides classroom and curricular implications for the teaching and learning of NOS.

1. Introduction

The Nature of Science (NOS) and Scientific Inquiry (SI) are often considered to be critical components of science education [1-4] [6-8] as they contribute to acquisition of both scientific literacy and decision-making skills [1-6].

The aim of the study reported in this paper was to: identify the NOS views held by undergraduate students of the University of Malta and to investigate possible differences in views between:

- Science and non-science students
- Science students in different years of study
- Male and female students

2. Nature of Science and Scientific Inquiry

There are various definitions of the terms NOS and SI. However a widely accepted definition is that proposed in Liang et al. [8], based on Lederman (1992) which states that: 'the nature of science and scientific inquiry refers to the epistemology of science, the values and beliefs inherent to scientific knowledge and its development' [8:3].

There are various debates about whether NOS and SI are distinct or whether SI is an aspect of NOS. While Lederman [9] draws a distinction between the two terms, other authors [10-13] argue that one cannot separate the cognitive aspect of the development of scientific knowledge from the epistemological framework and social context within which that knowledge is developing [12]. In the study reported in this paper, SI was regarded as an aspect of NOS [7][8].

Liang et al. [7] identify seven important aspects of NOS: the 'Tentativeness of Scientific Knowledge'; 'Observations and Inferences'; 'Subjectivity and Objectivity in science'; 'Creativity and Rationality in science', the 'Social and Cultural Embeddedness in Science', 'Scientific Theories and Laws' and 'Scientific Methods' [7: 3-4].
NOS views tend to have implications on various issues including moral issues [14-16], decision-making [5] [17-19], science learning [14] [20-22] and scientific literacy [1-2] [4] [6].
It is hence important to know what views undergraduates, especially those studying science, have. These students are academically successful individuals, who will probably pursue careers of responsibility that will require a proper understanding of the NOS and SI [23].

3. Method

3.1 Data Collection

The 'Student Understanding of Science and Scientific Inquiry' (SUSSI) questionnaire which was developed by Liang et al. [7] [8], was chosen as the data collection tool of the study. It was developed for use with undergraduates and is based on six fundamental aspects of NOS [7]. Each aspect is tested through four Likert-scale items followed by an open question where the respondent has to explain the views expressed in the corresponding first part. Data were collected using a convenience sampling strategy. A total of 343 responses were collected randomly from science and non-science students.

3.2 Data Analysis

The analysis of results is mainly focused on the Likert items. Initially each statement was numbered such that a score of 5 represented the most adequate view while a score of 1 represented the most inadequate view. The mean of each participant on each of the components and on the whole questionnaire was then determined. Further analysis of the individual sub-scales was carried out by classifying the responses into three categories: a score of 1 or 2 represented an inadequate view; a score of 4 or 5 represented an adequate view while a score of 3 represented an intermediate or transitional view. Chi square analysis for both the mean and the individual sub-scales was used to compare the various subgroups. Due to the low response to the open questions as well as the difficulty encountered in classifying them, these responses were only used to illustrate and expand the views expressed in some of the corresponding Likert items.

4. Results

4.1 Views of all participants

Fig. 1 summarizes the mean results of all participants on all six SUSSI components. C1 (Observations and Inferences) and C2 (Change of Scientific Theories) had the highest percentage of adequate views when looking at the mean values. However, looking at the Likert sub-scales and the open questions suggests that these views are in fact transitional.

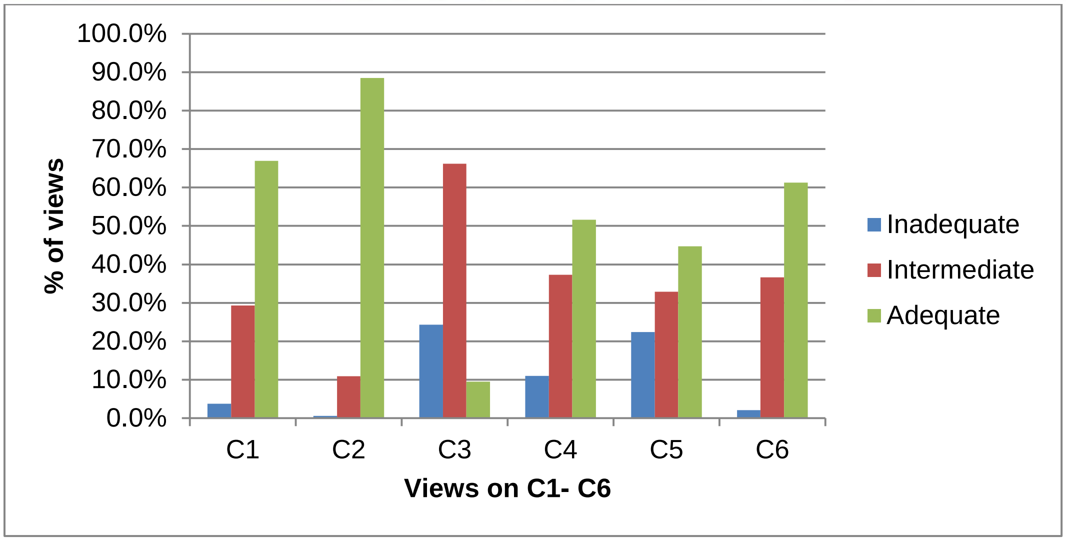

Fig. 1- *The Percentage of Inadequate, Intermediate and Adequate Views for C1- C6 based on the mean***.**

Less adequate views were in turn observed on C4 (Social and Cultural Influence on Science), C5 (Imagination and Creativity in Scientific Investigation) and C6 (Methodology and Scientific Investigation). Furthermore participants held a strong polarity of views on C4 and C5. This implies that they either held a strongly adequate view or a strongly inadequate view. A similar result was reported in Golabek et al. [24] where undergraduate science teachers held a strong polarity of views on four components of the NOS.
The distinction between laws and theories (C3) in turn appeared to be the most problematic for Maltese students. In fact, similar to other undergraduates [25] [26], a widely held misconception is that laws are more certain than theories and that theories eventually become laws.

4.2 Views of Non- Science and Science Students

Fig. 2 compares the mean results of Non-Science and Science students for all six components. The two groups held similar views on the tentative nature of the NOS, the distinction between laws and theories

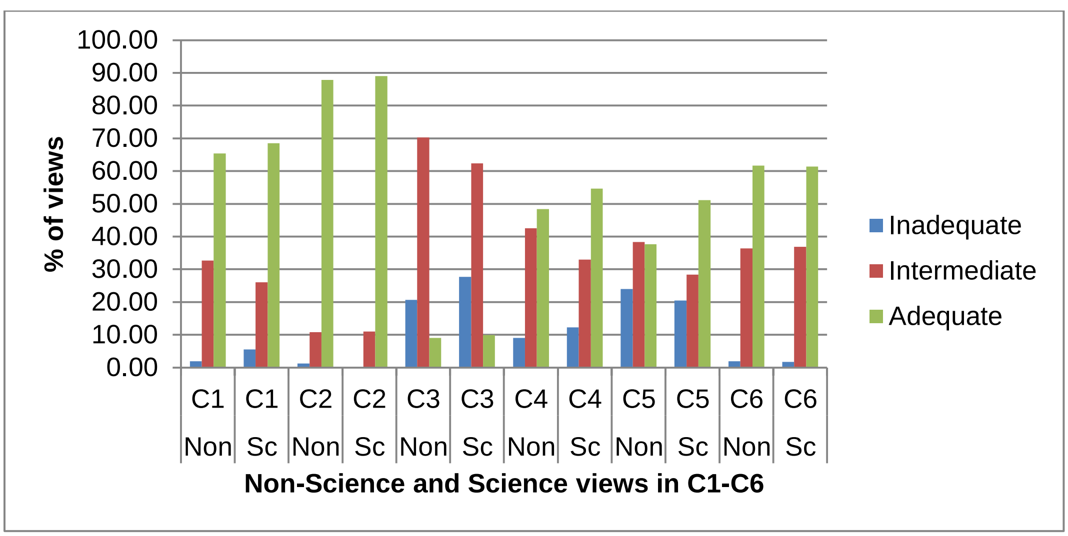

Fig. 2- *The views of Non-Science (Non) and Science (Sc) students on C1-C6 based on the mean*

and the scientific method. One noticeable difference was the presence of extreme views in C1 (Observations and Inferences) and C4 (Social and Cultural Influence on Science). Based on both results, science students held a higher percentage of inadequate and adequate views than non-science students. Such polarity can be attributed to the fact that being more specialized in the discipline, science students are more certain about their views.

The greatest difference among the two groups however was in the imaginative and creative aspect of the NOS (C5). Based on the mean, science students held a greater percentage of adequate views with a difference of 13.44% while the Likert result showed a percentage difference of 12%. Moreover chi square analysis showed that these differences are statistically significant. Such a finding is similar to that of other studies [23] [26]. As Parker et al. [26] suggest, most science students “saw creativity as an essential attribute for scientists” [26: 1685].

Variation by year of study of science students in turn yielded no consistent pattern in most components, while gender differences were completely absent in all six aspects.

5. Conclusion

Thus the findings of this study show that Maltese undergraduates tend to have transitional to inadequate NOS views. Moreover science and non-science students exhibited similar views on most components. Such similarity was also evident in science students in different years of study. This implies that greater exposure to science education does not have a significant effect on students’ views. Current international reform documents suggest that a decrease in the breadth of content and an increase in depth, would allow students to get a better grip of interdisciplinary frameworks including the NOS [27]. This implies that time should be allotted to the actual teaching of the construct to adequately shift these views as one cannot assume that by learning the content of a discipline an epistemological framework of the knowledge is attained [28]. To actually facilitate the learning of NOS, the cognitive objectives of the lessons should be targeted to do so. Timelines of the history of science, history of science stories and developed NOS instruments can all be used to teach the construct and possibly alter existing conceptual frameworks [28].

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