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

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Main aim of the study:

Investigate the NOS views of post-secondary lecturers in Malta.

Post-secondary lecturers' taught part-time or full-time in either of the following institutions:

- University of Malta [UOM]
- Malta College of Arts Science and Technology[MCAST]
- All the sixth forms in Malta

They either taught science, a science-related area and/or Philosophy, Religious Knowledge or Theology.

Compare these views by:

- Age bracket
- Lecturing experience
- Area of specialisation
- Closest, traditional science area
- Gender
- Highest qualification

The study utilised a **mixed-methods approach**.

•A ready-made questionnaire (Student Understanding of Science and Scientific Inquiry [SUSSI] developed by Liang, Chen, Chen, Kaya, Adams, Macklin and Ebenezer, 2008) was distributed to 1403 lecturers.

•A total of 252 responses were collected yielding a margin of error of 5.59% at 95% confidence interval.

•Ten interviews were carried out.

What is the Nature of Science [NOS]?

A widely accepted definition of the NOS and SI

"the nature of science and scientific inquiry refers to the epistemology of science, the values and beliefs inherent to scientific knowledge and its development." (Liang, Chen, Chen, Kaya, Adams, Macklin and Ebenezer, 2008 from Lederman, 1992)


Observations and Inferences
Methodology and Scientific Investigation
Change of Scientific theories
NOS
Imagination and Creativity in Scientific Investigations
Scientific laws vs. Scientific theories
Social and Cultural influence on Science

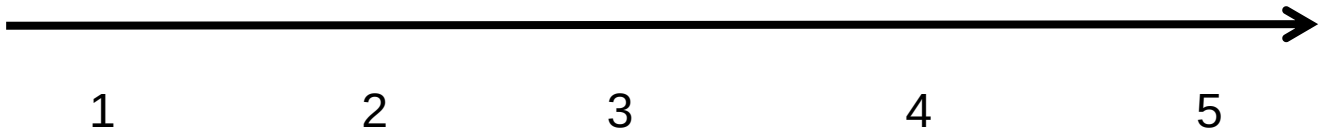
Sample Question

A	Scientists' observations of the same event may be different because the scientists' prior knowledge may affect their observations.	SD	D	U	A	SA
B	Scientists' observations of the same event will be the same because scientists are objective.	SD	D	U	A	SA
C	Scientists' observations of the same event will be the same because observations are facts.	SD	D	U	A	SA
D	Scientists may make different interpretations based on the same observations.	SD	D	U	A	SA
Explain why you think that scientists' observations and interpretations of the same event are the same **OR** different? Provide examples to support your answer.						

Analysis of the Likert statements

A) Mean

Each statement was numbered such that:



Most Inadequate

Most adequate

The mean of each component was then worked out.

B) Individual Likert statements

- Score of 1 or 2 – inadequate view
- Score of 3 – intermediate or transitional view
- Score of 4 or 5 – adequate view

All components had a skewed distribution to the right - so the Kruskal-Wallis test was used to compare the views of lecturers in the various sub-groups.

A large number of open responses was obtained.

These were classified as:

- Inadequate (1)
- Intermediate (2)
- Adequate (3)
- Unclassifiable (0)

Based on the rubric developed by Liang et al. (2009) in Miller et al. (2010).

The Kendall's tau-b test was carried out to see if there is agreement between the open and closed responses

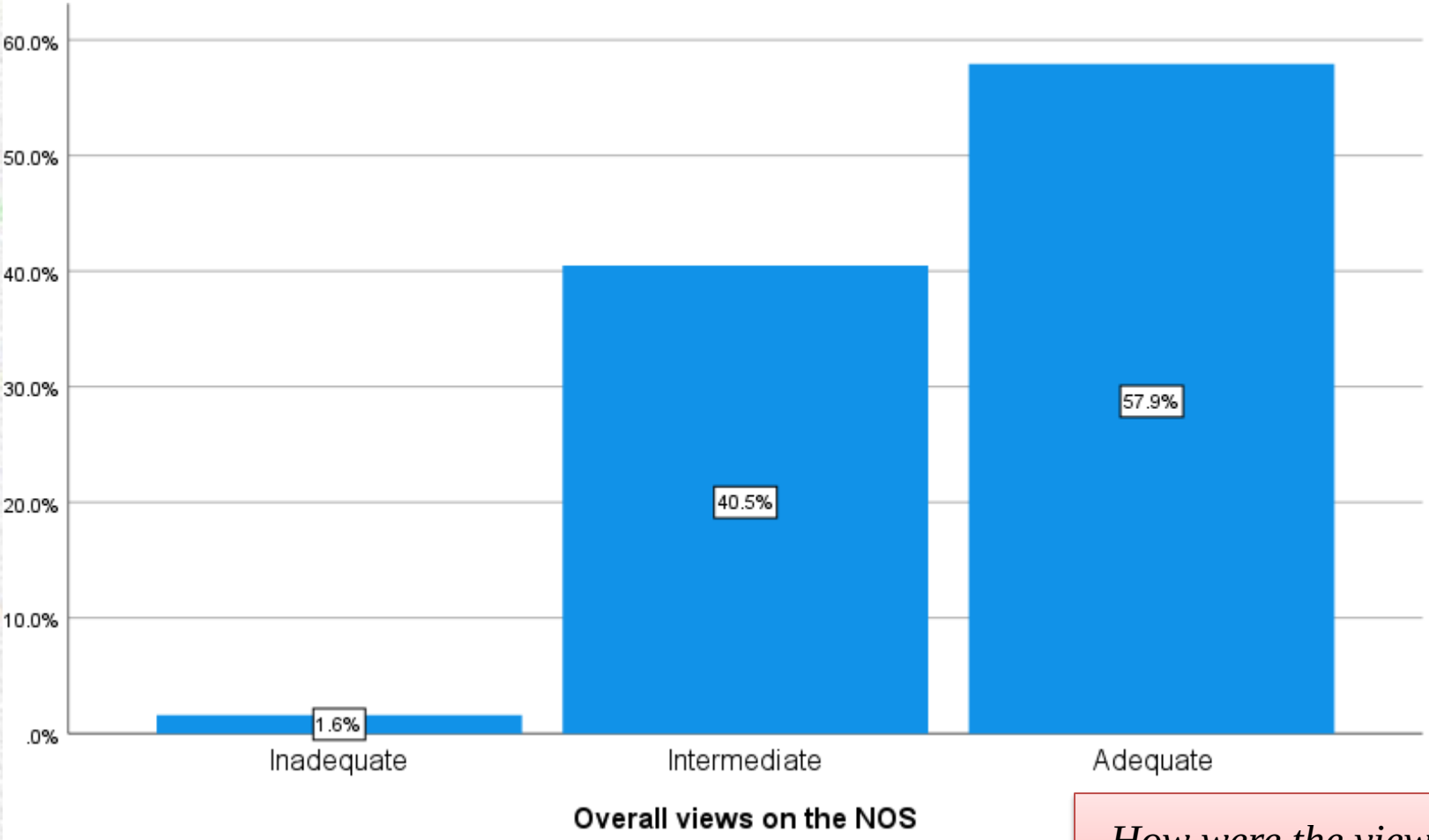
Interviews were analysed in two ways:

1. Inductive coding

   Codes → Coding frames (many times hierarchical) → themes

2. Using the rubric of the open responses to help better align the data.

Views of all participants based on the Likert statements



How were the views overall?

Mean scores for each component:

- Change of scientific theories (87.7%)
- Scientific methodology (73.0%)
- Social and cultural influence on science (68.7%)
- Imagination and creativity in science (66.3%)
- Observations and inferences (62.7%)
- Scientific laws vs. theories (21.0%)

There was agreement between the closed and open questions although the open-questions showed a higher percentage of intermediate views.

Which component had the lowest percentage of adequate views?

Generally, interview data presented these findings:

Change of Scientific Theories

"Any theory can be challenged by new data coming up, by new approaches being tested."
(P4: 3/11/2020)

Imagination and Creativity

"This means you have to be a little creative from the very start, even in designing the experiment, the techniques used, maybe you won't be when analysing the data, as during data analysis, like we were saying, to decrease that bias which we mentioned earlier, data analysis has to be within a set of parameters that are set before."
(P10: 11/12/2020)

Generally, interview data presented these findings:

Scientific Laws vs. Theories

"I believe that a law is more sure than a theory. Because I think even in general laws are…everyone has to abide by the laws which are in place. So, for sure laws are...I think they are more...a law is stronger than a theory."
(P8: 10/11/2020)

"As you move from hypothesis, to theory, to law, the level of certainty increases."
(P7: 7/ 11/2020)

Variation in the different sub-groups

Variation by age group and lecturing experience yielded no significant differences on any of the components

Variation by gender yielded a significant difference on scientific laws vs. theories where males exhibited better views.

However, when comparing to other studies, results appeared to be ambivalent and inconclusive.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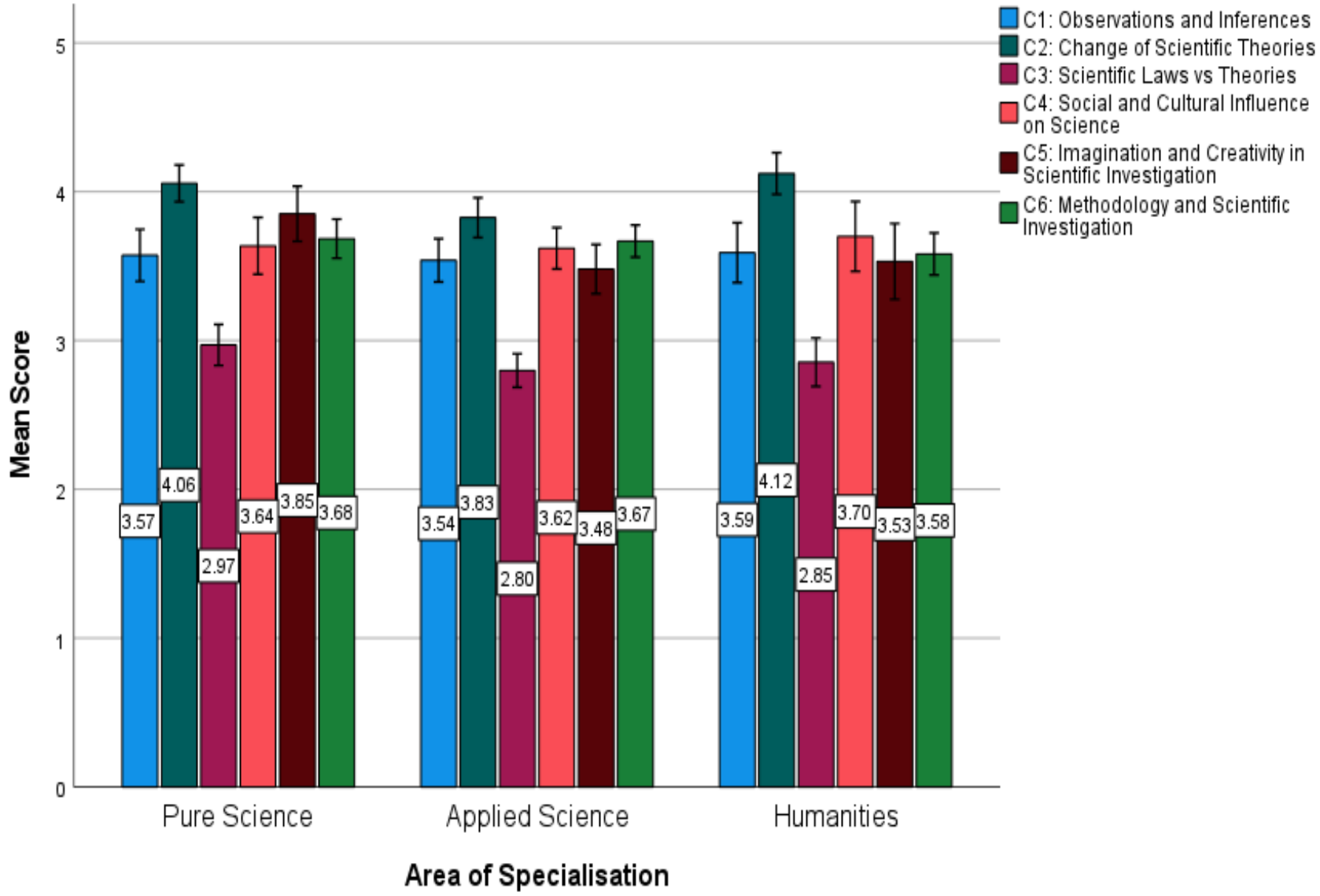
Variation by area of specialisation



Variation by area of specialisation

	Pure Science	Applied Science	Humanities
Observations and Inferences	**3.57**	**3.54**	**3.59**
Change of Scientific Theories	**4.06**	**3.83**	**4.12**
Scientific Laws vs. Theories	**2.97**	**2.80**	**2.85**
Social and Cultural Influence on Science	**3.64**	**3.62**	**3.70**
Imagination and Creativity in Scientific Investigation	**3.85**	**3.48**	**3.53**
Methodology in Scientific Investigation	3.68	3.67	3.58

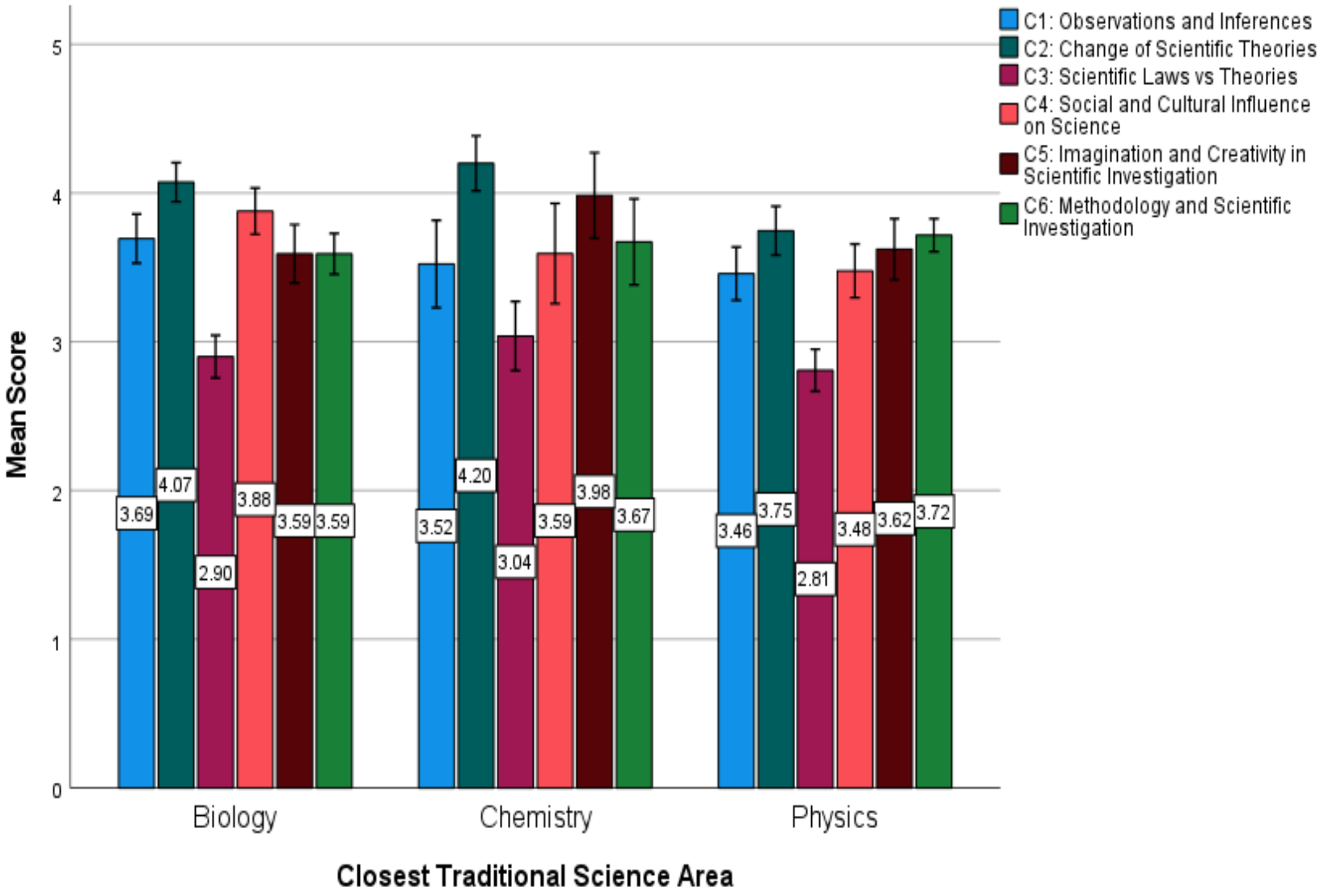
Which group had the lowest means on most components?

Variation by area of specialisation:

Applied science lecturers held more naïve views on 5 NOS components with differences being statistically significant on **change of scientific theories** and **imagination and creativity in science.**

This was attributed to **lack of prior reflection** (Irez, 2006) on the NOS as applied science lecturers are more concerned with the practicality of science rather than the epistemological underpinnings of the knowledge.

Variation by closest, traditional science area



Variation by closest, traditional science area

	Biology	Chemistry	Physics
Observations and Inferences	**3.69**	**3.52**	**3.46**
Change of Scientific Theories	**4.07**	**4.20**	**3.75**
Scientific Laws vs. Theories	**2.90**	**3.04**	**2.81**
Social and Cultural Influence on Science	**3.88**	**3.59**	**3.48**
Imagination and Creativity in Scientific Investigation	3.59	3.98	3.62
Methodology in Scientific Investigation	3.59	3.67	3.72

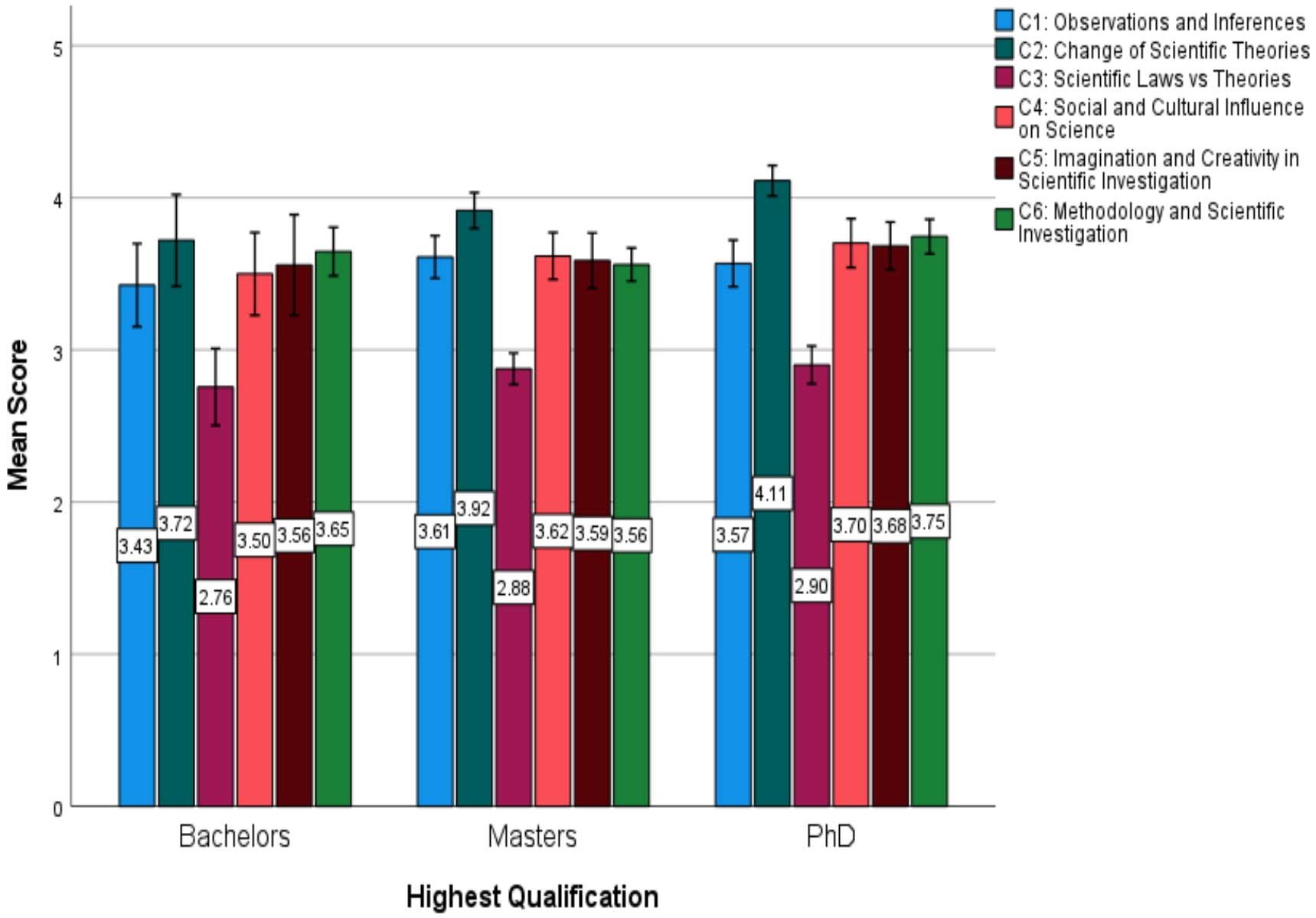
Which group had the lowest means on most components?

Variation by area of closest, traditional science area

Physics lecturers held more naïve views on 4 NOS tenets with differences being statistically significant on **change of scientific theories** and the **social and cultural embeddedness of science**.

This was similar to what was found in other studies (Vella Bondin, 2016) and was attributed to the mathematical basis of Physics that makes science appear more absolute.

Variation by highest qualification



Variation by highest qualification

	Bachelors	Masters	PhD
Observations and Inferences	3.43	3.61	3.57
Change of Scientific Theories	**3.72**	**3.92**	**4.11**
Scientific Laws vs. Theories	**2.76**	**2.88**	**2.90**
Social and Cultural Influence on Science	**3.50**	**3.62**	**3.70**
Imagination and Creativity in Scientific Investigation	**3.56**	**3.59**	**3.68**
Methodology in Scientific Investigation	3.65	3.56	3.75

Which group had the highest means on most components?

Variation by highest qualification

Views on the NOS appeared to improve by higher qualification on 4 NOS components.

The difference was statistically significant on **change of scientific theories** where lecturers with a PhD had better views than those with a Masters or a Bachelors.

There were two lecturers who also mentioned their PhD in the interviews and how this contributed to their ideas on the matter.

It was concluded that a higher the qualification leads to more exposure to research, its subjective and creative nature and the philosophical aspect of science that comes in when one is defending his/ her doctoral thesis. This contributes to better NOS views.

Conclusion

1) This study shows that most post-secondary lecturers held **adequate** views on most NOS components. This is a promising result showing that the initial steps have already been made in the right direction.

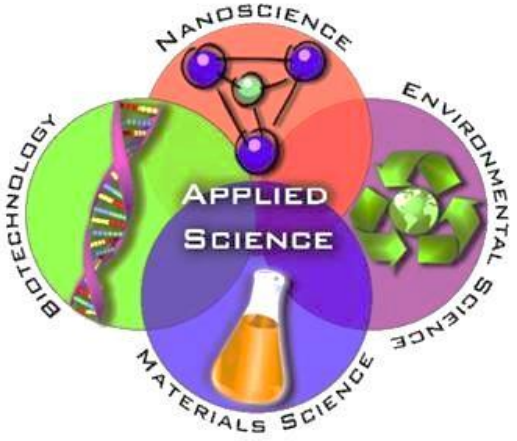
Conclusion

2) When viewing the results on “scientific laws vs. theories” post-secondary lecturers tended to have inadequate views on this component.

Considering this, as Wong and Hodson (2008) put it, one starts to **question the use of the term ‘law’ in science as this tends to give a false sense of certainty.**

Conclusion

3) A **greater NOS component should be incorporated in applied science courses** as both lecturers and their students may occupy or would eventually occupy important decision-making positions in society that would require an adequate NOS understanding.



Thank you!! ☺ Any questions?