Solomon's paradox in scientific lab reports: Helping students to become communicators.

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1. Introduction and Problem Statement

The scientific report is a staple assessment tool in the undergraduate laboratory, and a key component in a professional physicist's toolbox. Similarly, recent government reviews have noted that excellent scientific literacy is heavily desired by employer's wishing to find their recent graduates to be 'work-ready' [1]. Traditionally, this kind of communication has been taught to students as an implicit, technical skill; that there is a right and wrong way, and students must be assessed enough times throughout their undergraduate career to learn the 'right' way to write a report. What is less emphasized however, is that the scientific lab report represents an insight into a student's expression of their ideas, values, and attitudes towards physics. When applied to the use of discourse analysis, this is known as their epistemic stance. The scientific report also represents a unique perspective on a student's ability to comprehend a particular physics experiment or concept. By the very nature of this type of assessment, it is almost a completely authentic, unguided look at a students' use of sense-making – the term given to a student's ability to make sense of epistemological and conceptual issues [2].

In this talk, I report on the initial results of a scientific writing exercise designed as part of a wider undergraduate laboratory curriculum development. The design of guided scientific writing exercises using a historical and epistemological analysis will be discussed. Analysis of answers given by introductory undergraduate physics students to a series of guided worksheets reveals that epistemic distancing plays a large role in students' difficulties in producing comprehensive scientific writing. In particular, we find that students can express quite complex cognitive reasoning and expression when critiquing exemplar work that is not their own, but do not tend to carry that forward when producing their own writing. We also find that students tend to use two-clause predictive or counterfactual conditionals as an indicator of their epistemic stance.

2. Methodology

To make some difference in helping students to write proficient scientific documents, we undertake a number of initiatives.

2.1 Epistemological analysis of scientific writing

First, through analysis of expertly written scientific work, analysis of a sample of student submissions, and a detailed study of the literature in this area, we draw up epistemological characteristics for scientific reports. We then asked students as part of a laboratory class to write single paragraphs after their practical work each week. Each paragraph pertained to a different section of a scientific report.

We analyzed the students' submissions and developed a categorization scheme to validate the epistemological characteristics.

2.2 Students' concept image of scientific writing

We developed guided, open-ended exercises to interrogate students' concept image of scientific writing, and their use of sense-making when reading reports. Students were presented with weekly samples of scientific writing, each pertaining to a different section of a lab report. The subject of the lab report was deliberately chosen to be around a topic that was at an appropriate level for the student cohort but with which they would have little familiarity. Students were asked to answer open-ended questions regarding the level of detail, structure, content, and coherence of the sample writing.

2.3 Meta-cognition in developing an epistemic stance

In a third exercise, a different cohort of students from those in 2.1 were asked to write individual sections of a scientific report each week, after undertaking an introductory laboratory session. The exercise was part of the formative / summative assessment for their laboratory class. Thematic coding is used to determine and evaluate students' strategies in developing an epistemic stance while writing. We similarly compare students' submissions with their answer to the previous exercise to look for interference or aspects of meta-cognitive application when writing reports.

3. Results

3.1 Epistemological analysis

The analysis revealed that we could design a set of epistemological characteristics for a scientific report. In all, we found six characteristics that ranged from how the report is constructed to the linguistic choices used.

3.2 Concept image of scientific writing and 3.3 Meta-cognition in developing an epistemic stance

The analysis revealed that, by and large, students see a scientific report as an implicit technical document intended solely to demonstrate an experimental procedure to others. Ideas such as expressions of holistic judgement, historical critique, or context based reasoning are largely absent from students' concept image. However, analysis also reveals that students can express quite complex cognitive reasoning when asked explicitly to explain flaws in example written physical explanations.

When writing scientific work, section 3.3, we find that students, when asked to synthesize their own ideas, do not display the same level of cognitive reasoning as when they are asked to critique the work of others. We interpret this in the framework of epistemic distancing. Epistemic distancing is an oft used technique by students to soften their stance when trying to create safe spaces in which to sensemake. Here, we argue that in the scientific report, students tend to use epistemic distancing to soften their words as a way of either avoiding taking an epistemic stance, or as a method of conflict resolution albeit between what they feel they know, and what they feel they should say.

4. Conclusions

We have designed both guided and unguided open-ended exercises to probe students understanding of writing scientific reports. Thematic analysis of written answers has shown that there are general epistemological characteristics that make up a scientific report, that students see scientific writing as a technical rather than practical skill, and that students are not very good at following their own advice: This is the Solomon's paradox to which the title refers.

References

[1] Wakeham review of STEM degree provision and graduate employability.

[2] Conlin LD, "*The use of epistemic distancing to create a safe space for sensemaking in small group tutorials"*