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Producing a Scientific Explanation in Physics

What It Entails and Challenges Students Face

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KEY IMPLICATIONS

- Producing different types of scientific explanations requires different styles of thinking and reasoning—descriptive for interpretive explanations and narrative for causal explanations.
- Producing a scientific explanation requires students to develop representational competencies, which are unique to the content and context in which the representations are used to think and reason about the phenomenon.

BACKGROUND

The ability to produce scientific explanations is an important learning goal in our local physics curriculum. Yeo and Gilbert (2014) show that its production is a complex process of attending to multiple factors including its function, form and level of precision, abstractness and representations. These multiple factors might explain why students find producing an acceptable scientific explanation challenging. Without a clear idea of what it takes to produce a scientific explanation, assessing students' explanations might be difficult.

FOCUS OF STUDY

The purpose of this study was to characterise the nature of scientific explanations students produce in four key topics in physics—dynamics, thermal physics, electromagnetic induction and superposition, and how students went about producing them. This is done so that we can identify what it takes for students to produce an acceptable scientific explanation, and the challenges students face.

KEY FINDINGS

1. We found two main types of explanations produced by students—an interpretive and a causal explanation. An interpretive explanation tends towards a more descriptive form while a causal explanation takes a more narrative form.
2. More interpretive explanations were produced compared to causal explanations, even when a phenomenon could be explained interpretively or causally. This could reflect the students' belief in the nature of physics, as learnt at the A levels which comprises more scientific laws than theories.
3. Students who constructed acceptable scientific explanations were competent in orchestrating a set of coordinated representations of multiple modes (e.g., verbal, pictorial, gestural, mathematical, graphical), drawing from a unique system of representations (e.g., vectors, graphs) to help them shift their conceptualization of the phenomenon from concrete to abstract.
4. Students producing unacceptable explanations exhibited conceptual problems, cognitive challenges and difficulties in making sense of the purpose of the explanation sought. Conceptual problems were found to

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be linked to problems in making sense of the scientific representations in the context of the phenomenon. Cognitive problems were associated with the lack of students' awareness of the representational system used to think and reason about the phenomenon.

5. A scientific explanation can be described in terms of its coherence, the scientific model applied and its orientation towards the audience who seeks the explanation. Realizing these features entails the use of a system of representations that is unique to the characteristics of the topic. The type of explanation produced reflects one's belief in the nature of physics.

SIGNIFICANCE OF FINDINGS

The findings of this study show that producing a scientific explanation entails the need to go beyond content learning. It should focus on the conceptual, representational and epistemological competences and understanding as well.

The findings resulted in a framework of scientific explanations (see point 5 under Findings). Its value lies in its potential to bridge the language about representations with science education. Science teachers typically find it difficult to master the language of systemic functional linguistics (SFL) commonly used to analyze the representational demands of scientific texts. This framework contextualizes SFL model in the language of science, hence teachers do not need to learn a new language in order to analyze the representation/language demands of scientific texts (explanations), increasing its potential of utility.

Moving forward, future study will explore the use of the framework of scientific explanation to design interventions for teacher professional development and for physics teaching. Future research will also include the use of the framework of scientific explanation to characterize explanations of the other science disciplines so as to inform multidisciplinary teaching in science.

PARTICIPANTS

This study involved students taking H2 physics from four local junior colleges. A total of 346 think-aloud interviews of students producing scientific explanations of four key topics in physics were collected.

RESEARCH DESIGN

An exploratory mixed method approach was used to address the research questions.

REFERENCE

Yeo, J., & Gilbert, J.K. (2014). Constructing a scientific explanation—A narrative account. *International Journal of Science Education, 36*(11), 1902–1935.

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