Title: Understanding what ideas about scientific realism/anti-realism are being communicated and received within STEM higher education

Introduction

Scientific realism (hereby referred to as 'realism') is characterized by a belief that (a) there exists a world external to the subjective experiences of people and independent of thought and language, (b) this world is accessible to humanity through the scientific method and its resulting theories and (c) the information that is accessed about the world and the theories surrounding it counts as 'knowledge' of the world. While scientific realists may disagree on how accurately our current theories describe the world, they agree that it is theoretically possible, and thus a reasonable aim of science to give us an accurate representation of the world. (Godfrey-Smith 2003) However, as science grew more complex and abstract throughout its history, philosophers began to question the premise behind realism and form alternate 'anti-realist' accounts that disagree with at least one of the core premises behind realism. Several prominent examples of these alternative accounts include instrumentalism (it doesn't matter whether theories are accurate to the real world as long as they let us make good predictions), empiricism (our senses provide us with our only source of factual knowledge, so we cannot have access to the 'real world'), and constructivism (reality itself is dependent on what people say and think so it isn't possible for theories to describe the world as it exists independent to thought).

As it concerns the very nature of scientific knowledge, the discourse surrounding realism is highly influential within the field of philosophy of science. Most notably, realists and anti-realists disagree on other core issues such as the aim of science, how theories change and replace each other (a smaller part of a large debate surrounding the nature of the scientific method itself), whether or not unobservables (entities described by science but not observed) are as they are described by theories if they even exist, etc. While this discourse has remained largely within the philosophical community, its influence can extend beyond the philosophical, with several key ideas behind it influencing contemporary socio-political ideas and movements–most notably those involving trust in science. This influence doesn't escape the scientific community that inspired it either, with philosophers arguing that "practitioners of science already display an active engagement with issues that (if not in name, then in spirit) are central to the realism debate" (Votsis 2002).

Despite the academic acknowledgement of this mutual interdisciplinary engagement, it has yet to be extensively studied, especially from the perspective of science and how scientists interact with philosophy. Within this research, I intend to gather data about the philosophical beliefs of science students (since my focus is on education specifically). Then, to understand why they may believe what they do, I intend to turn towards understanding what they are taught, as most scientists likely undergo similar education. To ensure that the focus remains on the education of scientists specifically, I'll be studying educational content geared towards University level science students such as myself. Furthermore, while science education itself is its own independent field of study, its intersection with realism hasn't been extensively researched either, although it is notable that most of the work that has been done describes "the current dominance of anti-realist positions in science education, such as the dominant anti-realist constructivist learning theories" (Jackson 2005) and argue for the adoption of a more realist

approach. However, much of this work is theoretical and abstract, so with my work I intend to attempt to verify or disprove these observations and further understand science education by approaching it through a different, more grounded and practical lens.

Research Questions

- What do STEM majors believe about the nature of science and scientific theories? How does it affect their relationship with their career path and future?
- How are these beliefs impacted/influenced by the subtextual presentation of these ideas within higher educational content?

Research Design

Aim 1: ***Understand how physical science students respond to ideas about scientific realism.***

This will largely be conducted using a descriptive approach, through a series of surveys distributed to a large sample of University students in the natural/physical sciences. This survey will gather information about the students' plans for the future and their beliefs surrounding scientific realism, as well as a range of demographic data–including age, racial and gender identity, personality data, etc–to identify and further investigate any demographic related trends. To collect data about their philosophical beliefs, students will be asked to rate a series of statements designed to address different aspects of realist/anti-realist discourse (aims of science, status of unobservables, etc.) either as true/false or on a scale of agreement. Based on their responses, the students will then be sorted into the relevant philosophical category (realist, anti-realist, constructive empiricist, etc). This indirect approach will ensure that the data being collected is uniform and that the definitions of the different categories and what ideas they encompass are clear and known, reducing the amount of error and bias. Students will also be asked how they primarily learn, which resources they use the most, whether they prefer lectures or not, etc. so I can ascertain which kinds of educational content are being utilized the most, and whether they affect which philosophical beliefs the student picks up. I will also collect data about the desired career paths of the students, to specifically investigate whether there's a pattern in the beliefs of those looking to become scientists and conduct research after they graduate as they are the best representation of the future of the scientific community.

Aim 2: ***Investigate the communication of realist/anti-realist philosophical ideas within educational materials geared towards University students in the physical sciences.***

Most natural sciences programs and classes do not directly interact with the philosophical implications and discourse around their content. However, the act of describing or explaining something isn't neutral or objective, so the educator's philosophical beliefs will become embedded within the subtext of their work. I plan to analyze a series of educational content–ranging from textbooks to potentially lecture notes and transcripts, syllabi, and exams–which may vary depending on time constraints, budget and ability to acquire data. In this project, I will be analyzing the usage of specific ideas, word choices and writing structures employed within this content to try and expose subtextual themes and philosophical ideas related to realism in a process similar to Literary Analysis. In my analysis, I will be investigating the presentation of scientific theories in these texts, with a special focus on those that have

been contentious within the scientific community (such as theories within quantum or astrophysics) and those that have been 'replaced' or disputed but still remain in everyday use (such as Newtonian mechanics). I will also be focusing on the portrayal of the mathematical and conceptual aspects of scientific progress as well as how they relate to ideas about realism.

Intellectual Merit

With this work I hope to bring a fresh, grounded perspective to understanding science education and philosophy through the integration of a novel interdisciplinary approach. From a philosophical perspective, while discourse around scientific realism is nothing new there is a prominent lack of data about the beliefs of those outside the philosophical community, especially those within the scientific one. Since beliefs held by scientists about the accuracy and 'reality' of theories also may play a role in how, when and why the scientific community handles certain aspects of the scientific process (such as periods of 'scientific revolution'), a better understanding of them may add more insight into the scientific method as it is practiced by the community. Similarly within education, the question of realism was largely approached through abstract theoretical and philosophical perspectives, focusing on what ideas should underpin science education without adequately understanding or discussing which ones currently do and why, and I intend to fill that gap in knowledge through this project. Additionally, while Literary analysis is an already established method of analysis within Literature, it has yet to be implemented within this specific area of study, thus if the method proves successful, it will open the possibility for research on a new similar scale.

Broader Impacts

Science is an inherently human endeavor and thus, many of its practices (including its teaching) are going to be affected by biases, personal beliefs and philosophy. While the true scale of these effects may be difficult if not impossible to measure, knowing that they exist places a certain amount of responsibility onto science communicators and educators to be aware of and deliberate about what ideas and beliefs they are communicating. This work will provide an understanding of how philosophical ideas are currently subtextually conveyed which could then be used to reverse engineer a natural/physical sciences syllabus or program which is built around more nuanced and deliberate ideas about scientific theories and methods. This will be especially useful for use in educational systems where students wouldn't otherwise encounter much interdisciplinary work as these philosophical ideas will ideally be built into an otherwise 'ordinary' STEM curriculum and can thus be taught in more STEM focused settings.

References

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