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THE BODILY PRODUCTION OF PHENOMENA IN THE SCIENCE LABORATORY: RECOGNIZING AN OVERLOOKED CONTENT

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This paper deals with a content that is largely overlooked in science education, that of the bodily production of science phenomena. Numerous accounts of scientist's work shows us that producing phenomena requires immense amounts of bodily labour, yet this is not recognised as something teachers need to teach and students learn in science education. Seeking to take charge of this tacit content, this paper addresses how the body is involved with materiality to produce physics phenomena, and in what terms this is learning physics content. The findings are applied to a secondary physics laboratory class, where we through video recordings seek to examine how students' bodies need to be educated to produce physics phenomena. The findings indicate that the bodily work that go into producing scientific phenomena is an inescapable part of learning scientific inquiry, and that the embodied knowledge gained in this regard is just as much a part of the subject physics as conceptual knowledge. Based on these findings, we argue that the body needs to be made explicit as content in science teaching and how it may enrich students' learning.

Keywords: Curriculum, body, phenomena

INTRODUCTION

In this paper we examine a little empirically studied content in science education, namely that of *producing the phenomena*. While accounts of science studies repeatedly reminds us of the hard physical labour required in the process of producing phenomena, this is typically not recognized as content in science education. The aim of this paper is thus to take charge of this tacit content, by examining the following questions: (1) How is the body involved with materiality in learning to produce physics phenomena? (2) In what terms is this learning science subject content?

Producing the phenomena in scientific research and science education

There are numerous empirical science studies showing the bodily involvement of scientists in producing phenomena. Knorr Cetina (1999), for example, show how manual labour is intrinsically a part of doing physics at the CERN. Pickering (1995) notes how also small-scale laboratory work in physics is not completely conceptual and planned beforehand, but the results of bit-by-bit tinkering through the making of machines. Pettersson (2011) illustrates the gendered nature of this kind of work. Science studies make evident the immense time experimental physicist spend on manual labour to produce and stabilize the phenomena necessary for getting data and the significance of these manual skills for being recognized and hired as a physicist at laboratories. Together they suggest four ways in how the body is involved with materiality in learning to produce phenomena, which also are relevant in relation to scientific inquiry in science education. These are 1) hands-on embodied labour is an indispensable part of doing physics inquiry, 2) the machines and bodily techniques produced need to be of a kind that stabilises the production of the phenomena so that physicist reliably can produce them, 3) some phenomena can be produced by a machine built and run by a single scientist, but often collaboration between physicist are necessary and, 4) different categories of persons are deemed variously fit beforehand to manually carry out phenomena production.

Despite this empirical evidence of the centrality of the body for the production of phenomena, the role of the body is rarely treated as content teachers need to teach and for students to learn. Turning to major reviews of science education research, both historical accounts (e.g. Atkin & Black, 2003) and current reviews (e.g. Duit et al., 2014; Kelly & Licona, 2018), we find that this is not a content reflected on. When mentioned, the body is typically described as the other rather than a necessary requirement for thinking (e.g. Hofstein & Kind, 2012).

Theoretical background

Two theoretical frames inspire this paper. First, phenomenology (Leder, 1990) sensitises us to how primordial the body is for perception and experience. We tend to take the functioning body for granted. Leder (1990) termed this lack of awareness the "absent body". Second, we draw on pragmatism (Garrison, 2003) with its notion of learning as bodily mediated and related socio-cultural perspectives emphasizing the mediation of bodily action through artefacts (Wertsch et al., 1995). Knowing and learning is not just a matter of receiving direct and neutral stimuli from phenomena. Rather, to receive stimuli from and gain meaning of phenomena artefacts are developed, often through long-term tinkering. The body also needs to be educated about how to handle the artefacts or machines and of how it needs to be oriented to receive relevant stimuli.

METHOD

Video data was collected at a Danish secondary physics laboratory class. The science unit studied concerned the topic "light and sound", where students had to produce the phenomenon of invisibility of objects by refracting light and the Doppler effect by running with a sound producing device. Segments were selected for deep examination by repeated viewing, allowing authors to build shared interpretations and identifying critical incidents (Arthur et al., 2012).

A practical epistemological framework was used to analyse video recordings (Author & Colleague, 2002), which enabled examination of how the interactions between teachers, students and the material setting influenced the subject content being constructed and how their bodily actions influenced the direction of learning. The framework applies four analytical concepts, which were used for coding what in the educational situation allowed students to notice certain gaps in their knowledge and to construct new relations to what they already knew. In our presentation, we will include images of bodily movements.

RESULTS

Students used their bodies to manage equipment and register observations. Just like scientists, students needed to tinker in intimate transactions with materiality to produce the phenomena requested. The analysis of the task concerning the refraction of light showed that students noticed and filled gaps concerning how to position their bodies to produce the phenomenon of invisibility and filled them through tinkering in encounters, where they experimented with different correlations between bodies and materials. The assignment sheet was a fundamental encounter that influenced which gaps they noticed and which bodily relations they construed. Other central encounters also occurred between the students and the material world, where their sensorial experiences of the materials in relation to the concept of invisibility jointly resulted in different relations arising, and filling gaps by construing a repertoire of embodied experiences that helped them in the process of producing the phenomenon. The group could also be seen to recurrently adopt certain previously successful positions and mimic the successful ones of others to stabilize the production of the phenomena. Sometimes this non-conceptual way of learning to produce the phenomena worked reliably, but sometimes not. At the same time, they did not know how to communicate these skills and how they more generally could transact with materiality to produce phenomena.

Our study also indicates that the division of labour has importance for meaning making in the science classroom, and the kind of experience and learning that becomes available to students. Analysis of the task concerning the Doppler effect showed that different relations emerge when students were assigned different roles. The emergence of different relations consequently produced different opportunities for filling gaps. This has educational ramifications regarding the significance of learning to produce the phenomena.

DISCUSSION

In this paper, we focussed on embodied *doings* when producing phenomena. When tinkering, students draw on habits matured through a lifetime, such as using their eyes when asked to *see*. Yet, analysing students' habits of "seeing" it is not always effective. Considering the importance for physicists of being skilful in producing phenomena, and also the systematic exclusion of some bodies from physics (Pettersson, 2011), suggest that producing the phenomena needs to be made an explicit and important content of science education. While habits are essential to meaning making, this article raises the need to address whether prompting reflection on bodily ways may further deepen the students' understanding, and assist them in learning to tinker and communicate their findings regarding how to produce the phenomena? This also applies to the second finding that questions the affordances from coordinated actions, that in light of gender studies (Brickhouse, 2001), which show that cultural socialization offers girls less opportunities to tinker with machines and use common measuring equipment, raises questions as to who gets to do more learning.

There are also epistemological reasons to include producing the phenomena as an explicit and self-evident content in science education. The focus on the conceptual and theory-laden nature of science seems to have had the consequence that how scientific knowledge is produced from observing natural phenomena has been overlooked, although it is central for learning science and about the nature of science (Lederman, 2007). Furthermore, thinking about science and technology as means to predict the workings of nature to accomplish technical control, suggest an important role for science education in terms of not only teaching explanations, but also giving students a sense of control over their surroundings. This control cannot be gained without involving the body in technological transactions.

CONCLUSION

This study has implications for teaching science. Considering that the production precedes data, suggests that there is a core science content, which starts with learning to produce phenomena. This content is central not only because it produces data and explains the phenomena, but because it is part of gaining control over the phenomena and stabilise them. As such, in modelling teaching of this content, the education of the body is just as important as educating the mind. A generic terminology must therefore be developed through further research about how teachers can support students in gaining control over natural phenomena through manual work and tinkering. The 'absent body' (Leder, 1990) needs to be made present.

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