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EDITORIAL

Increasing Access to Science and Engineering—the Role of Multimodality

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The idea for this special issue of *Designs for Learning* emerged during the 8th International Conference on Multimodality (8ICOM), held in Cape Town in December 2016. During that conference, a special stream of papers was organised, all of which addressed the question of science and/or engineering teaching from a multimodal perspective. In this editorial we discuss the issue of multimodal access to science and engineering and introduce the papers in the special issue.

Keywords: multimodality; access to science; equity; science education; engineering education

In December 2016, Cape Town, South Africa, played host to the 8th International Conference on Multimodality, which included a special stream of papers that explored multimodal social semiotic approaches to science and engineering education. That there should have been such a strong focus on the teaching and learning of science was fitting, given the setting of Cape Town, South Africa. Only a few months before the conference, South Africa was rocked by escalating student protests aimed at, in the first instance, scrapping high university fees and, in the second instance, 'decolonising' university curricula. These student movements came to be succinctly captured in two Twitter hashtags: #FeesMustFall and #RhodesMustFall. The University of Cape Town, in particular, was the setting for a now infamous exchange in which one student argued that science, in its entirety, is a Western construct and thus needed to 'fall'. The original #ScienceMustFall video and myriad commentary (largely negative in response) remains available on YouTube.

And yet, at 8ICOM, there was a sizeable group of researchers from various contexts all of whom believed that science was important and—given the conference theme—that multimodal approaches could benefit the teaching and learning of science. The then-recent protests nonetheless prompted consideration of *why* we believed science was more than just a western, colonial construction.

While calls for the decolonisation of the content taught in undergraduate social sciences and humanities have found some traction—why study Western authors and themes when there are perfectly viable African alternatives?—most scientists would agree that the *content* of science is not bound to or in the service of a particular culture. What differentiates science from the social sciences and humanities is that, in the terms used by Bernstein (1999), science has a hierarchical knowledge structure in which knowledge grows by explaining more and more phenomena *using the same system.* A new theory in science cannot just explain a new phenomenon, it must also explain everything the old theory explained as well. Bernstein likens this kind of knowledge production to a growing triangle, with the goal being to widen the base to include more phenomena into the same overarching explanatory structure.

In contrast, Bernstein suggests that the humanities and social sciences are more horizontally structured. In his view, knowledge production in these disciplines occurs through the introduction of new explanatory 'languages', which act as new ways to interpret the world. Within such disciplines, it is not necessary for one particular interpretation to be coherent with another. Indeed, it is often the very incompatibility of approaches that is sought after—adopting different methodological and theoretical lenses allows us to notice quite different aspects of the same situation. This signals that in these disciplines knowledge is far more context-dependent, tentative and disputed. And if knowledge is contested, a discussion of decolonisation of the content taught can always be had. But what about science then?

The history of science is one of continual revision—what Kuhn (2012/1962) termed *scientific revolutions*. For example the beginning of the 20th century saw radical changes to our understanding of fundamental physics with the introduction of general relativity and quantum mechanics. These two branches of physics were created to explain a number of new observations, that violated the predictions of classical physics. However, instead of totally rejecting the 'old' theory, both of these new theories subsume classical physics. Throughout these massive

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upheavals in science there has always been one guiding principle: any 'new' science must plausibly explain everything the 'old' science could. Hence, in the future, any Grand Unifying Theory of physics will need to comprehensively explain the phenomena described by Newtonian mechanics, quantum mechanics and general relativity (Airey 2012). Science strives towards a universal, decontextualized description of the world around us—and as such, it is not the property of any particular cultural group.

So is science impervious to calls for decolonisation? Far from it! The question is rather *what* should be decolonised? We suggest that the real issue at stake in #ScienceMustFall was in fact, *unequal access* to science. Clearly this is not a 'new' observation: Burke *et al* (2017), building on the work of Fraser (2009) have shown how higher education is characterised by widening gaps in participation and misrecognition along race, gender and class lines. In science, specifically, Latour (1987) has demonstrated how 'centres of calculation' come to control the means of production of science through 'black boxing' technologies and the ever-increasing technicality of science texts. Similarly, Nordling (2018) recently described the barriers to entry that still exist in the South African science community. As such, despite the fact that #ScienceMustFall was roundly dismissed as misguided, particularly outside of South Africa, for us it nonetheless raised important questions about access to higher education, and to science, and the benefits this bestows. The issue is not that science itself must fall, but rather that access to science remains unequally distributed. It is here that we suggest that the study of the representational means by which scientific knowledge is produced and disseminated offers one way of potentially increasing such access.

Science is inherently multimodal, not least due to the fact that scientific phenomena are often either 'invisible' or highly abstract. Moreover, access to the technologies and modes of representation of 'science' is highly skewed, both within countries (i.e. along lines of class or ethnicity) and across countries. Each of the papers in this special issue serves to illustrate one way in which a multimodal conceptualisation of science teaching allows for enhanced access to semiotic resources that facilitate improved access to scientific concepts on the part of learners. The papers are located across two geographic poles: in the north, Sweden and Denmark, and in the South, South Africa. They also span two educational contexts: primary and secondary school, and the university.

The special issue is made up of the following six papers:

Transduction and Science Learning: Multimodality in the Physics Laboratory. By Trevor Volkwyn, John Airey, Bor Gregorcic, and Filip Heijkenskjöld. DOI: http://doi.org/10.16993/dfl.118

Didactical Design Principles to Apply When Introducing Student-generated Digital Multimodal Representations in the Science Classroom. By Mette Fredslund Andersen and Nicolai Munksby. DOI: http://doi.org/10.16993/dfl.100

Thermal Cameras as a Semiotic Resource for Inquiry in a South African Township School Context. By Gilbert Dolo, Jesper Haglund, and Konrad Schönborn. DOI: http://doi.org/10.16993/dfl.96

Hot Vision: Affordances of Infrared Cameras in Investigating Thermal Phenomena. By Robin Samuelsson, Maja Elmgren and Jesper Haglund. DOI: http://doi.org/10.16993/dfl.94

Unpacking the Hertzsprung-Russell Diagram: A Social Semiotic Analysis of the Disciplinary and Pedagogical Affordances of a Central Resource in Astronomy. By John Airey and Urban Eriksson. DOI: http://doi.org/10.16993/dfl.137

Teaching, Learning, and Employing Analytical Frameworks as Performance: Analysis of a Quantitative Literacy Event in Applied Mechanics. By Zachary Simpson and Robert Prince. DOI: http://doi.org/10.16993/dfl.95

In the first paper in this special issue, Volkwyn *et al* (2019) conducted a practical classroom laboratory exercise, involving a technical measurement device, with high school students in Sweden. Their research demonstrates the central role of *transduction*, which they define as "the movement of semiotic material from one mode (or semiotic system) to another" for both doing science and learning science. The authors suggest that an understanding of such transductive processes potentially allows teachers to do two things: provide timely input to student discussions that 'nudge' students in fruitful directions, and assess the student learning that is taking place. The paper also introduces the notion of a *persistent placeholder* as a permanent semiotic resource for summarizing and 'offloading' the results of student interactions with various semiotic resources. The authors demonstrate how such placeholders can function as both a springboard and coordinating hub for continued student interaction.

Fredslund Andersen and Munksby (2018) conducted their study with 7th and 8th grade school learners in Denmark. Their study seeks to develop students' awareness of the conceptual affordances of representations, and they offer three design principles for introducing students to the multimodal nature of science culture. This involves introduction to the required representational forms, scaffolded practical work with these forms, and digital production of science texts.

Dolo *et al* (2018) also work with school learners, but at township schools in South Africa. They make use of infrared cameras in the science classroom in order to demonstrate the pedagogical and disciplinary affordances of technology for science learning in disadvantaged contexts. Infrared cameras are also deployed in this way in the special issue by Samuelsson *et al* (2019) albeit with laboratory instructors and undergraduate university students of chemistry in Sweden. Both Dolo *et al* and Samuelsson *et al* not only show how technology offers affordances for science learning in different cultural settings, they also show that technology constrains action and talk on the part of learners, fixing these in particular ways.

In their paper, Airey and Eriksson (2019) examine the relationship between disciplinary knowledge and its representation. They use a social semiotic perspective to analyse how the disciplinary affordances of a central representational resource in astronomy have developed into the rich resource used today. Their analysis results in four observations about the ways in which disciplinary experts create and employ the affordances of their disciplinary resources, and the ways in which undergraduate students may interpret such resources when meeting them for the first time. The authors describe how unpacking a resource to create one with higher pedagogical affordance may be a useful strategy for negotiating the barriers to learning that highly-packed, authentic, content-rich, disciplinary resources often present.

Finally, working with undergraduate civil engineering students in South Africa, in a module on applied mechanics, Simpson and Prince (2018) argue that teaching and learning events are cultural performances that situate individuals in relation to the scientific phenomena they study, a fact unaccounted for in traditional frameworks on science learning. A multimodal lens, in their study, allowed for acknowledgement of how artefacts (semiotic, technological and myriad others) are not mere 'tools' that passively represent human endeavour; rather, they 'fix' human endeavour to particular points in time and space.

In conclusion, each of these papers addresses the issue of access to scientific knowledge with a focus on multimodal approaches to classroom pedagogy. However, it is important to remember that the issue of access extends well-beyond the four walls of the classroom—it is a global issue that speaks to inequalities in the wider processes by which science is produced and disseminated. While this last point cannot be addressed in this special issue, it was an ever-present theme within the 8ICOM conference and in our view remains as one of the most important challenges of our time.

Competing Interests

The authors have no competing interests to declare.

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