Conceptualizing Authenticity and Relevance of Science Education in Interactional Terms

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Abstract: Authenticity and relevance are two terms that are often mentioned when criticizing the content and practice of science education in school. This paper examines the meaning of authenticity and relevance in science education from an interactional perspective. Particularly, it compares and contrasts authenticity with productive disciplinary engagement, and relevance with expansive framing. We then use this comparison to discuss the tension between maintaining accountability to the discipline and fostering students' agency and authority; a tension that is not sufficiently addressed in science education literature that addresses the conceptualization of authenticity and relevance. We suggest a research agenda that aims to resolve this tension by problematizing and articulating in fine detail the theoretical meaning of productive disciplinary engagement and expansive framing for science classrooms that are deeply immersed in authentic scientific practices and discourse.

Keywords: science education, teaching, learning, authenticity, relevance, interaction

Relevance and authenticity in science education

Since the beginning of the 20th century, science educators have been concerned with questions about which topics should be taught in science classrooms and what activities should students engage in while learning these topics (Meltzer & Otero, 2015). Authenticity and relevance are two terms that are often mentioned in current debates concerning these issues (e.g., Osborne & Dillon, 2008). Relevance was traditionally considered to be personally and societally driven, and as a central attribute of science education that can be productively applied in daily life decisions and future careers (Hurd, 1998). In their review of the meaning of the term relevance in science education, Stuckey, Hofstein, Mamlok-Naaman, and Eilks (2013) pointed to four main sources of relevance: (1) students' interest, (2) students' understanding of issues related to their lives; (3) issues of personal importance or need; and (4) issues with real-life effects on individuals and society. They described the first and second sources of relevance as driven by meaningfulness, and the third and fourth as driven by consequences (personal, societal and vocational). Interestingly, relevance to the content and to the epistemological and cultural nature of STEM disciplines has not been explicitly considered in the discussion of the relevance of science education, though in our opinion, it should.

Authenticity was traditionally considered to be disciplinary driven, reflecting the desire to simulate, in the classroom, "real" scientific practices, with the epistemological and reasoning aspects that such practices entail (e.g., Chinn & Malhotra, 2002). However, recent discussions of authenticity in science education argue implicitly, and often explicitly, for students' and teachers' agency in determining what authenticity means, and talk about authenticity as emerging from the interaction between canonical science, teachers and students (Rahm, Miller, Hartley, & Moore, 2003) or about positioning learners in collaborative social contexts so as to explore *their own* scientific questions (Calabrese-Barton, 1998; Rivera Maulucci, Brown, Grey, & Sullivan, 2014). Hence, if the discussion of relevance started from students' agency and went on to gradually include society as legitimate agents in defining what is relevant science education, an opposite trend is apparent in the case of authenticity, the discourse of which started from the canonical disciplines as the main determining agent, and gradually came to include students, teachers and society as legitimate agents in determining what authentic scientific practice in science classroom means.

When considered this way, the boundaries between relevance and authenticity of science education become blurred, the two concepts seem to complement one another, and the meanings of both seem to emerge from the interactions between the canonical STEM disciplines, the students, the teachers, and the society in which all these agents function. This paper examines the constructs of authenticity and relevance from an interactional perspective, comparing and contrasting them, respectively, with two related interactional constructs suggested by the late Randy Engle to describe productive classroom practices: productive disciplinary engagement (Engle & Conant, 2002) and expansive framing (Engle, 2006).

Productive disciplinary engagement and expansive framing

Randi Engle and colleagues examined social framing in classrooms, focusing on classroom discussions. Engle and Conant (2002) coined the term *productive disciplinary engagement* (PDE) to theoretically describe a specific type of student engagement that “combines, moment-by-moment, interactional aspects of student engagement with ideas of what constitutes productive discourse in a content domain” (p. 400). To explain the sense in which discussions are productive, Engle defined an additional theoretical construct—*expansive framing*. Engle argued that transfer is more likely to occur when learning contexts are socially framed by the teacher as part of a broader ongoing intellectual conversation in which students are actively involved. Engle termed this framing "expansive framing", as opposed to "bounded framing" with respect to the setting (time, place) and roles of the participants (Engle, 2006).

Drawing parallels

The engagement of students in what constitutes productive discourse in a content domain (i.e., PDE) is certainly consistent with engaging students in “real” scientific practices, which is the central principle of the traditional take on authenticity in science education. The question is whether we can regard PDE as an interactional parallel of authenticity, and if so, what is gained by this parallelism. The answer is complex. Rahm et al. (2003) wrote that “the focus on designing and establishing authentic science learning environments and tasks has neglected to ask what authenticity means, to whom, and according to whom” (p. 738). The same problematizing applies also, to some extent, to productive disciplinary engagement. Namely, a fair question would be to ask what *productivity* means, to whom, and according to whom. Yet, we would argue that thinking of authenticity in the science classroom as PDE allows us to better articulate the problem presented by Rahm and her colleagues, shifting the focus of our attention from the list of topics and practices that constitute authentic science education to the students’ actual engagement with these topics and practices. Such refocusing explicates an unresolved tension between fostering accountability to the discipline, while maintaining students’ authority over the ideas that are being discussed (see for example Engle & Faux, 2006).

To highlight the importance of addressing this tension, let us consider the perspective of authenticity that Buxton (2006) refers to as the “youth-center perspective on authenticity”, and which she considers to be the extreme alternative to the canonical science perspective on authenticity. According to the youth-center perspective, learning is authentic only when its starting point is the student's desires, interests and needs. Yet studies that adopt this perspective are usually conducted in informal education settings, such as enrichment programs that target young children from families with multiple socio-economic related problems (e.g., Calabrese-Barton, 1998). In this context it is very easy to accept the domination of students’ needs and interest over disciplinary demands; however, when considering science education at the advanced high school levels, accountability to the discipline is as crucial as is fostering students’ agency and authority. This tension has not been explicitly and deeply considered in the treatment of authenticity in science education. We argue that the interactional lens that PDE offers can, at least potentially, lead to a more accurate and stronger conceptualisation of authenticity. In the next sections we elaborate how examining authenticity in science education through an interactional lens, namely considering it as a case of PDE and articulating what productivity in learning science means, to whom, and according to whom, can also contribute to the development of the theoretical and operational definitions of PDE.

Another parallel we wish to draw is between relevance and expansive framing. We argue that expansive framing articulates the construct of relevance in interactional terms and grounds it in classroom practice. Here again, the power of the interactional perspective is in focusing our attention on the engagement of students. Instead of debating the list of topics and activities that should be part of a relevant science curriculum, it draws our attention to the way in which these topics and activities are being used by teachers in their classrooms. Such refocusing suggests that the explicit links that science teachers are able to make between topics and activities in the official curriculum and the world outside of the immediate classroom reality, are at least as influential in creating a sense of relevance in their students as are the actual topics that are formally being taught. Just as the notion of expansive framing deepens and enriches our understanding of productive disciplinary engagement, the notion of relevance can add and enrich our understanding of authenticity.

Research agenda

Engle and Conant (2002) wrote that “productive disciplinary engagement can be fostered by designing learning environments that support (a) problematizing subject matter, (b) giving students authority to address such problems, (c) holding students accountable to others and to shared disciplinary norms, and (d) providing students with relevant resources” (p. 399). Although we agree with these design principles, we argue that to be able to truly address the tension between students' authority and accountability to the discipline, we must problematize and examine in fine detail attempts to apply PDE design principles to the instruction and learning of science in contexts in which accountability to the discipline is crucial (e.g., science at the honors and advanced high school levels as well as undergraduate levels). Such contexts emphasize the need to articulate the disciplinary specificity and multidimensionality of the terms productive and engagement in PDE.

Engle and Conant suggested that "what constitutes productive depends on the discipline, the specific task and topic, and where students are when they begin addressing a problem" (p. 403). We suggest that in science classrooms that are immersed in authentic scientific practices and discourse, such productivity should be manifested by (1) conceptual and epistemological development, (2) development of scientific creativity and self-efficacy, and (3) identity construction as a person, citizen and future professional. We also agree with Engle and Conant that "evidence for student engagement can best be seen by analyzing students' discourse" (p. 402), but argue, as in the case of productivity, that we should better articulate what we are searching for. Specifically, we look for discourse markers that reflect (1) specific positioning of students and teachers with regard to each other, the task and the content, (2) deeply meaningful use of disciplinary concepts and habits of thought, and (3) social, personal, deeply affective, and future-oriented engagement with scientific content (Kapon, forthcoming; Levrini, Fantini, Pecori, Tasquier, & Levin, 2015). In our consideration of expansive framing, we are therefore interested not only in examining how the teacher frames the interaction for the student, but also how the student frames it, and the degree to which these frames overlap and demonstrate deep intersubjectivity (Wertsch, 1984).

Concrete examples

Levrini et al. (2015) identified forms of productive complexities that intrinsically characterize scientific practices and discourse in modern physics. Such complexities allow content to be problematized in a productive way for students. Specifically, they "educationally reconstructed" (Duit, Gropengießer, & Kattmann, 2005) the secondary school curriculum on thermodynamics to embody the following attributes: (1) Multi-perspectiveness – the same physics content was analyzed from two different perspectives (the macroscopic and microscopic approaches to studying thermodynamics), each characterized by a specific approach to the content. (2) Multi-dimensionality – the two approaches were analyzed and compared according to different dimensions involved in physics, i.e. their conceptual, experimental and formal implications, as well as their philosophical-epistemological peculiarities. (3) Longitudinality – the approaches to modeling systems and processes used in the thermodynamics unit were systematically compared with models used in theories previously studied by the students (classical mechanics and special relativity).

Levrini et al. (2015) analyzed data gathered from an extended intervention that implemented the designed curriculum in a 12th grade class of 20 students. They identified five discursive markers used to determine the student's progress in making the learned content relevant on a personal level and to its conceptual understanding. These markers include expressions that are (1) personal "signatures", i.e. idiosyncratic expressions involving personal tastes and purposes, (2) grounded in the discipline, (3) thick, in the sense that they involve a metacognitive and epistemological dimension, (4) non-incidental, in the sense that they are used consistently throughout classroom activities, and (5) carriers of social relationships that position the student within the classroom community.

Kapon (forthcoming) examined the engagement and learning of a group of eight 11th and 12th grade students while working in their school laboratory on long-term (18 month) open-ended research projects in physics. All eight students had the same project advisor: a physics teacher who is a member of a research community of teacher-researchers that associates several schools ("Acheret Center," 2006). Analysis revealed not only the development of the students' understanding and mastering of content and skills, but also identified discursive markers that highlight their progress towards the internalization of scientific habits of thought such as (1) spontaneous use of scientific standards of evaluation, (2) tendency to refine thought through model-measurement interactions, (3) persistence, (4) sensitivity to scientific aesthetics, and (5) self-efficacy with regard to scientific practices and procedures. These learning gains were connected to the particular nature of mentorship that the students received. The discourse between the students and the advisor positioned both students and advisor in a *joint* inquiry, like that of research apprenticeship, in which the expansive framing by the advisor aimed to relate the students' activities in the school laboratory to "real" science. The advisor explicitly cultivated students' interest and agency with regard to science, and nurtured their creativity, even when this cultivation meant *temporarily* compromising accountability to the discipline.

The discourse markers mentioned above (Kapon, forthcoming; Levrini et al., 2015) articulate the notion of authentic engagement with a scientific discipline and in so doing they further develop the concept of PDE. Specifically, while the term *productive* in PDE refers only to disciplinary productivity, its markers are very generic, whereas our discourse markers are deeply grounded in the discipline. Our markers are also sensitive to the authenticity of the engagement from the students' perspective and thus articulate the way in which authenticity and relevance emerge from the interaction between the discipline, the students, the teachers, and the society in which they function.

Conclusion

In this paper we argued that re-conceptualizing the theoretical meaning of authenticity and relevance in interactional terms—particularly by drawing parallels between authenticity and productive disciplinary engagement and between relevance and expansive framing—articulates a tension between accountability to the discipline and fostering students' agency and authority. We suggested a research agenda that aims to resolve this tension by problematizing and articulating, in fine detail, the theoretical meaning of productive disciplinary engagement and expansive framing for science classrooms that are deeply immersed in authentic scientific practices and discourse.

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