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Curriculum materials support teachers in the promotion of argumentation in science teaching: A case study

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HIGHLIGHTS

- Argumentation scarcely occurs in science classrooms.
- Initiatives focused on promoting classroom argumentation report modest successes.
- Curriculum materials support teacher's use and orchestration of argumentation.

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ABSTRACT

This case study set out to explore the potential of curriculum materials to scaffold classroom argumentation in a primary-school science classroom in Chile. One teacher and thirty students participated in the study. The teacher was given curriculum materials especially designed to foster argumentation during the teaching of physics. Lessons were videotaped and classroom discourse analysed. The analyses show that the teacher was progressively able to promote argumentation, both in whole-class and group-work interactions, from lesson 1: argumentative interactions were increasingly responsive and engaging, and the teacher's group supervision was progressively argumentatively oriented. The implications for professional development are discussed herein.

1. Introduction

Argumentation, as the discursive practice aimed at increasing (or decreasing) the acceptability of controversial standpoints (van Eemeren & Grootendorst, 1992), has been recognised as both the means and the goal of science education (Driver, Newton, & Osborne, 2000; Jiménez-Aleixandre & Erduran, 2008; Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2013). Consequently, national initiatives in different countries have included argumentation as one of the key goals of science teaching. The problem is that argumentation scarcely occurs in science classrooms (Larrain, Freire, & Howe, 2014; Roth, Druker, Garnier, & Gallimore, 2006). So the question is why – after decades of advancing argumentation as a key goal of science education, and arguing for the need to *argue to learn science* – is it scarcely exercised in classrooms?

Argumentation is a discursive activity that emerges when speakers, in order to deal with controversial issues, provide additional pieces of discourse to support a given claim (see Leitão, 2000; Toulmin, 1958). Part of the problem is that argumentation is a type of language that is highly sensible to context, requiring specific conditions in order to emerge: a polemic theme; indeterminated discussion's outcome; participants' dispositions to change their views; familiarity with the audience; specific interactional goals; argumentative instructions; previous knowledge; and participants' symmetric relations, among others (see Andriessen & Coirier, 1999; Asterhan & Schwarz, 2016; Leitão, 2009). Classrooms do not normally accomplish these conditions so in order to promote argumentation in classrooms a careful design is needed (Andriessen & Schwarz, 2009; Leitão, 2009).

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Are teachers prepared not only to talk in an entirely different way but also to transform the classroom conditions and design instruction considering all the relevant variables for promoting argumentation in the science classroom? More relevantly, how can in-service teachers prepare for promoting argumentation in classrooms?

1.1. Professional development and classroom practices change: the role of feedback

Arguably the most popular and globally disseminated form of teachers' professional development has been out-school short-term one-off workshops, focused mainly on the transmission of knowledge (Birman, Desimone, Porter, & Garet, 2000; Garet, Porter, Andrew, & Desimone, 2001). This has been the case, at least in countries such as Chile (Ávalos, 2007; Larrain, 2017; Montecinos, 2008). These workshops have worked based on the tacit epistemological assumption that practice is oriented by knowledge, that is, that first one needs to know and only then will one act accordingly. Teachers' failure to transform their practices therefore is believed to have been due to a lack of knowledge about the desired practices and how to achieve them.

Evidence shows that this type of in-service teachers' professional development is not appropriate to promoting instructional changes (Loucks-Horsley, Hewson, Love, & Stiles, 1998; Montecinos, 2008). Pedagogical change has been an elusive achievement indeed (Hord & Hall, 2001; Sarason, 1996). In the case of Chile, despite many attempts to provide professional development to in-service teachers, teaching is still teacher-centred and organised around the transmission of knowledge (Preiss, Larraín, & Valenzuela, 2011; Preiss, 2009; Radovic & Preiss, 2010). Various studies have converged, showing that effective professional development initiatives are characterised by content focus, active learning, adequate duration and sustainment over time, coherence between PD and teachers' beliefs and school and national policies, and collective participation, among others (Desimone, 2009; Garet et al., 2001). Following these findings, and sociocultural and pragmatist theories of learning (Dewey, 1939; Lave & Wenger, 1991; Rogoff, 1995; among many others), professional initiatives around the world have become increasingly active and peer-work based, including collaborative spaces to discuss and reflect around their own practices as the pivotal aspect for change (Ávalos, 2011; Edwards-Groves & Hardy, 2013; Englert & Tarrant, 1995; Flitton & Warwick, 2013; Harford & MacRuairc, 2008; Lom & Sullenger, 2011; Louca, Tzialli, Skoulia, & Constantinou, 2013; Nehring, Laboy, & Catarius, 2010; Nelson & Slavit, 2007; Sch, 1983). Again, knowledge is seen as a necessary condition for change (see Desimone, 2009), although in this case it should be collaboratively constructed and based on the participants' own teaching practices. In addition, video-based reflections have been considered particularly effective in fostering practical change insofar as teachers can discuss relevant examples and evidence of desired practices (Harford & MacRuairc, 2008).

However, the effectiveness of these components of teachers' professional development has been mostly reported by teachers, and less so by direct evidence of changes in classroom practices (Garet et al., 2001; Samaras & Gismondi, 1998), with a comparative focus on their differential effectiveness (Desimone, 2009; Garet et al., 2001; Wilson, 2013). In fact, evidence on dialogical teaching initiatives suggests that collaborative reflections and video-based workshops are not sufficient (see Louca et al., 2013; Reznitskaya & Wilkinson, 2015; Wells & Arauz, 2006). Successful studies have involved the use of specific and focused one-to-one feedback, coaching and/or mentoring (Bennett, 2010; Chinn, Anderson, & Waggoner, 2001; Kiemer, Gröschner, Pehmer, & Seidel, 2015; Rathel, Drasgow, Brown, & Marshall, 2013; Sedova, Sedlacek, & Svaricek, 2016), suggesting that direct and focused feedback is one effective way to change instructional practices (Auld, Belfiore, & Scheeler, 2010; Brinko, 1993).

1.2. Professional development for classroom argumentation: teachers' knowledge as a prerequisite?

The literature reports modest successes relating to teachers' professional development in promoting classroom argumentation in science teaching. McNeill and Knight (2013) conducted three workshop series focused on the development of pedagogical content knowledge for science argumentation. Seventy secondary teachers attended the workshops. The results showed that, although teachers increased their ability to discuss some aspects of students' argumentative writing, they did not increase their ability to apply argumentation in their classroom discussions. Osborne et al. (2013) evaluated the effect of a collaborative reflective professional development initiative involving distributed leadership for the use of argumentation in science classrooms. Four schools and two lead teachers participated in a two-year project. The lead teacher participated in a series of workshops (5) in which they worked with videotaped materials, followed by periodic meetings with researchers, albeit with scant feedback. Between workshops, lead teachers had to work with their colleagues in embedding argumentation in lessons. The results showed no differences between the experimental and control conditions in student outcomes. This is surprising considering that this initiative assumes that change should be driven from within schools, involving the schools in their entirety in the development of the PD process. The authors concluded that there being fewer than the 30 h of PD suggested by the literature (Guskey & Yoon, 2009), and the need for teachers to develop deep understandings of scientific argumentation, might be responsible for the absence of effects. Pimentel and McNeill (2013) accounted for the lack of teachers' success in orchestrating whole-class discussions in secondary classrooms, pointing to teachers' beliefs: their beliefs about students' ability and its role in discussions; about external constraints such as time; and beliefs about their own capability to lead discussions. Regarding the latter, according to Sampson and Blanchard (2012), part of the problem is that teachers do not have proficiency in arguing, insofar as they have trouble supporting arguments with data.

Therefore, among scholars working on argumentation in science teaching there is a shared view that knowledge and beliefs are a prerequisite for practice, and that they should be developed in order to change teachers' instructional practices (Beyer & Davis, 2008; McNeill, González-Howard, Katsh-Singer, & Loper, 2017; Pimentel & McNeill, 2013; Sampson & Blanchard, 2012). We also think that teachers' knowledge and beliefs are relevant conditions (see Ávalos, 2011); while the latter provides the epistemological soil to value argumentation as an essential part of scientific knowledge construction and learning, the former enables teachers to manage pragmatic, epistemic and discursive conditions for arguing in the classroom, thus allowing them to design argumentative lessons. However, the relationship between practice and knowledge is not linear but complex (Clarke & Hollingsworth, 2002; Wilkinson et al., 2017). Pianta and colleagues conducted a study to explore the effect of teachers' knowledge of, and skill in, identifying high-quality teacher–child interactions on the observed interactions during instruction (Pianta et al., 2014). The results showed that, contrary to expectations, the observed behaviour was a leading indicator of changes in identification skills. The authors concluded that the 'observed behaviour was a more powerful driver of change in identification skills, than vice versa' (p.