EPISTEMIC FEATURES OF SCIENCE TEACHERS' TALK: COMPARING THE DISCURSIVE PRACTICES OF TWO SCIENCE TEACHERS

Andri Christodoulou[1] *and Jonathan Osborne*[2]
[1] King's College London
[2] Stanford University

Abstract: Contemporary reform efforts within science education emphasise the importance of teaching the content and methods of science, as well as promoting an understanding of the nature of scientific knowledge and the practices of science. One way to promote the epistemic nature of scientific practices in science classrooms is through teaching science using collaborative discourse and argumentation. Argumentation can be seen as a form of epistemic discourse, which can be fundamental to the development of students' epistemological understanding. Yet, little analysis exists of the epistemic discourse initiated by teachers, either in ordinary or argumentation-based instruction in order to model epistemic discourse for the students and prompt them to engage in this form of classroom talk. Therefore, this study, examined the epistemic discourse initiated by two science teachers observed teaching the same groups of Year 9 and Year 10 students throughout a school year, both during ordinary and in argumentation-based instruction. Epistemic discourse was framed based on epistemic operations such as explaining, describing, exemplifying etc. The results suggest that during argument-based instruction the epistemic operations of justification, prompts for justification and prompts for evidence were the most frequent and were dependent on the teachers' views of the nature of argumentation and its use in science education.

Keywords: epistemic discourse, epistemic practices, argumentation, secondary science, case studies

INTRODUCTION

During the last two decades and in light of considerations about scientific literacy and 'science for all' (AAAS, 1989) there has been a major shift in the goals of science education. That is, reform efforts in several countries in Europe, and the United States, now acknowledge the need for students to develop an understanding of issues such as the importance of evidence in the practice of science, the cultural and social influences of scientists, and the strengths and limitations that scientific knowledge possesses, in addition to aims about conceptual understanding and practical work (NRC, 1996, 2011; Millar& Osborne, 1998; Osborne & Dillon, 2008). An in-depth understanding of science means students should not only be aware of 'what we know' but also of 'how we know what we know and why we choose to believe it over alternatives' (Duschl, 2008, p.163). Thus, science educators need to address the epistemic practices that characterise the scientific endeavour. Kelly (2008) defines epistemic practices as 'the specific ways members of a community propose, justify, evaluate, and legitimise knowledge claims within a disciplinary framework' (p.99). This study argues that one way to foreground the epistemic practices of science within science education is to view the teaching of science as argument.

Argumentation is an integral practice of science which explores the construction and critique of scientific knowledge fostering not only the critical scepticism that is the hallmark of the scientist but also enhancing student conceptual understanding (Kuhn, 1993, Osborne, 2010). During argumentation-based instruction, students use evidence to support their claims

and evaluate other individuals' claims and, in this manner, are enculturated into the discursive practices of scientists (Erduran & Jiménez-Alexaindre, 2008). Consequently, argumentation constitutes a form of epistemic discourse (Sandoval & Morrison, 2003); a way of talking that can help students develop a more informed view of the nature of science and its epistemic practices. Epistemic discourse could include instances of asking for evidence to support and justify a claim; making students consider opposing views and critically evaluate which one is better and why; explicit mention of the nature of evidence that students need to be using in their explanations and of the role of this evidence for their arguments; and providing or creating counter-arguments. The function of epistemic discourse is to help students acquire scientific knowledge whilst at the same time, engage students to the discursive and reasoning process necessary for that knowledge to be acquired.

Sandoval and Morrison (2003) argue that simply participating in activities where students need to construct their own explanations and provide evidence to support these explanations does not necessarily provide the means for students to develop an informed epistemological understanding. In their research, the students on which they focused had the opportunity to engage in such activities but at the end of the study, they did not demonstrate any substantial improvement to their understanding of the nature and role of scientific theories and evidence. Sandoval and Morrison (2003) add that students, in addition to engaging in such activities, need to be provided with opportunities to discuss the reasons and criteria they use for choosing one explanation over another, as well as to discuss the role of evidence for their explanations. As a consequence, 'to develop students' epistemological ideas, the nature of the discourse surrounding students' inquiry may be more important than the inquiry itself' (p.383). Ohlsson (1996) suggests that through an examination of the discursive actions of teachers and students, several epistemic operations can be identified, which promote higher-order thinking and understanding since 'collections of facts do not in and of themselves constitute understanding' (Ohlsson, 1996, p.48). These operations are Describing, Defining, Predicting, Exemplifying, Explaining, Critiquing (Arguing) and Evaluating. However, a careful examination of Ohlsson's list of epistemic actions shows that it is not exhaustive, as he suggests, since there could be other discursive epistemic operations carried out in classrooms, and especially the science classroom, such as compare and contrast, classifying, calculating and appealing to analogies and metaphors (Collins & Ferguson, 1993; Jiménez-Aleixandre et al., 2008; Mason, 1996). Utilising the notion of epistemic operations to analyse classroom talk during argumentation instruction is a way to identify the discursive actions of the teachers and find ways to help them model and further develop the use of epistemic discourse with their students.

RATIONALE

Research to date would suggest that there has been little analysis of the epistemic discourse initiated by teachers, either in ordinary or argumentation-based instruction. While there have been many studies of argumentation in the context of science education, many of these have focussed on student-student discourse and not on the nature of the discourse initiated by the teacher. As a result, this study aims to fill this gap in the literature. Specifically, the question of interest for this study, part of a professional development project aiming to help teachers incorporate argumentation into their everyday practices, was whether the use of argumentation-based activities enhanced the use of epistemic discourse in the science classroom when compared to 'ordinary' science lessons of two secondary science teachers.

CONTEXT OF THE STUDY

This study was conducted as part of a funded two-year Professional Development project (PD project hereafter) which aimed to help science teachers and their departments in four different schools to incorporate argumentation into their everyday practices. Argumentation was framed for the teachers based on Toulmin's (1958) framework of an argument, which consists of a claim; warrants or evidence; backings, rebuttals and qualifiers. Within each intervention school, two teachers acted as lead teachers for their departments. The lead teachers attended five workshop days during which they were introduced to the practice of argumentation, helped develop their knowledge of implementing argumentation in their science classrooms and at different age groups, and worked towards a dialogic perspective of science instruction. Subsequently, these eight teachers acted as lead teachers for their departments organising departmental reflective meetings and providing support to the science teachers of their own departments, which attempted to use argumentation activities in their science lessons.

METHODS AND ANALYSIS

This study utilised a qualitative case study design to create a detailed account of two teachers using argumentation and their students. The nature of the case studies developed were 'exploratory' emphasising the investigation of an event with the intent to create further hypotheses for future investigation (Yin, 2009). Two science teachers, from two secondary schools in London, one with a Year 9 class (13-14 years old) and one with a Year 10 class (14-15 years old), were followed throughout a school year. As a result, 13 lessons (6 argument-based) and 12 (4 argument-based) lessons respectively of the two teachers were observed in their classrooms. Lessons were video-recorded to capture the verbal interactions between teacher and students. The lessons observed focused on argumentation in different ways, varying in time, number of activities and topic investigated depending on the teacher's objectives and planning. Other data collected include teacher interviews to acquire a fuller picture of their conceptions about science, its nature and its practices and their beliefs about science teaching, learning and argumentation. In addition informal discussions with teachers about the lessons observed were hold and recorded in field notes.

Participant sampling was based on convenience sampling aiming at teachers participating in the PD project, who would be prepared to share more of their time with the researcher and allow for lesson observations for an extensive period of time (one school year). Moreover, criteria such as the willingness to use argumentation even after the end of the PD project, confidence in teaching while observed, demonstration of enthusiasm and commitment to the PD project and an interest in the use of argumentation for teaching and learning science, were utilised to identify the two participating teachers. T1, a male science teacher in his forties with 20 years of science teaching experience at a mixed-comprehensive secondary school located in a quiet, residential area in the north-west of Greater London. T2, was a female teacher in her twenties with 3 years of teaching experience working at a mixed-comprehensive, secondary science specialist school in the north-east of Greater London.

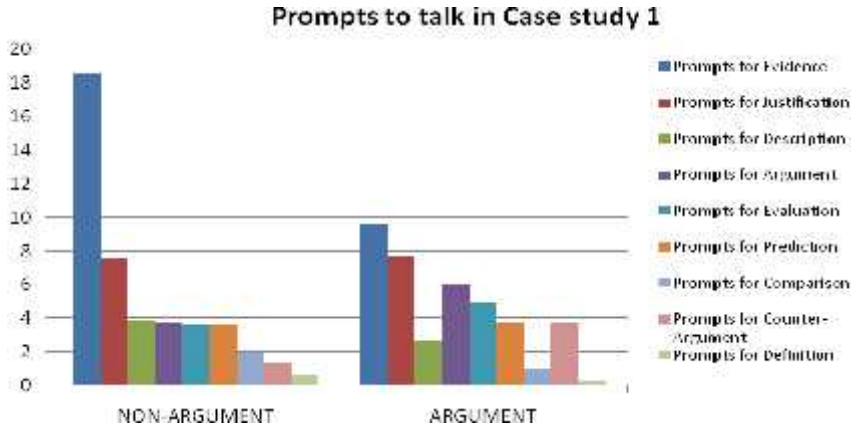
Thematic analysis was used to code the transcripts of the lessons (Boyatzis, 1998) based on a theoretical framework of epistemic operations synthesised from the literature (Jimenez-Aleixandre et al., 2008; Ohlsson, 1996; Pontecorvo & Girardet, 1993). The software for qualitative analysis Nvivo 8 facilitated the coding process of the data. Initially, a reiterative process of open coding was utilised aiming at identifying the main themes coming out of the teachers' responses. The next step of analysis involved the revision and refinement of the themes identified to create overarching categories from the initial themes and use these categories to look for patterns within the case. The epistemic operations identified were framed based on (a) epistemic operations *performed* by the teacher, which were the

discursive actions used by the teacher when s/he was attempting to explain, define, describe etc. an event and (b) the epistemic operations the teacher *prompted* students to engage in.

RESULTS

The analysis of the lesson transcripts for the two teachers, indicates that both teachers engaged in the epistemic practice of constructing knowledge claims through epistemic operations such as 'Provides Evidence/Information', 'Description, 'Explanation', 'Argument', Definition' and 'Generalisation'. In the two teachers' argumentation lessons, epistemic operations became more cognitively demanding and challenging as they started prompting students to provide their own arguments or provide justifications from evidence for their opinions/ideas. 'Justification' was utilised by both teachers, although not to the same extent. The justificatory aspect of the practice of argumentation was the strongest epistemic feature of T1's classroom talk, which was also one of the fundamental ways in which he conceptualised the notion of argumentation. Indeed 'the need to justify a viewpoint' was found to be the thematic emphasis in most of his argumentation lessons and the main way in which he distinguished between argumentation and non-argumentation lessons. What is more, T1 utilised 'Justification' and 'Prompts of Justification' as part of his non-argumentation lessons in a way and frequency, which were not substantively different to that of argumentation lessons (Figure 1).

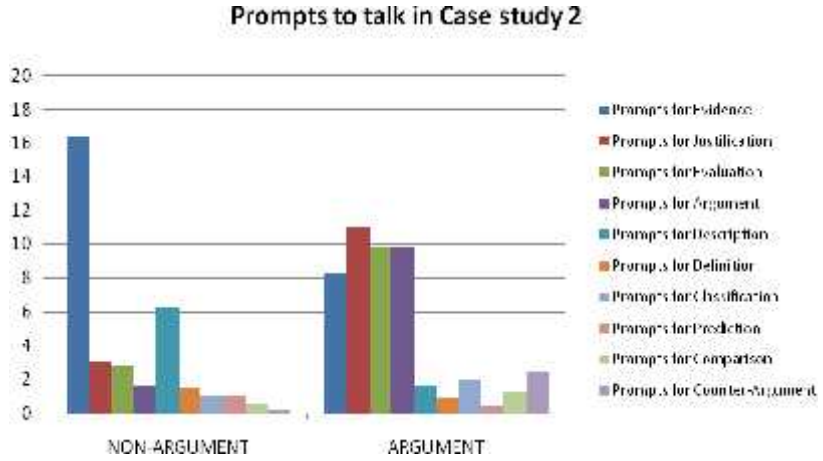
Fig1: The range of prompts in percentages T1 utilised as part of his argument and non-argument lessons



However, T1 did not consider other aspects of epistemic practices such as the need to evaluate knowledge claims and the need to portray to students the processes of evaluation and counter-argument that scientists often engage within their disciplines. As a result, attempts to evaluate claims critically and/or provide counter-arguments were less frequent, even in lessons where the argumentation activities focussed specifically on the evaluation of claims (Lesson 3).

In Case Study 2, T2 utilised 'Justification' and 'Prompts for Justification' consistently in her argumentation lessons, although this was not the case for her non-argumentation lessons, especially her use of 'Prompts for Justification', which was minimal (Figure 2). What is more, it was found that T2's use of justificatory talk was increasing as the year pasted, suggesting that she was still developing her use and understanding of argumentation as an instructional approach.

Fig2: The range of prompts in percentages that T2 utilised as part of her argument and non-argument lessons



Through the two case studies, it was established that the way in which the two teachers utilised epistemic operations and formulated their classroom talk was context-specific. In particular, the epistemic operations found in each teacher's talk depended on the type of lesson they were teaching (argumentation or non-argumentation) and within that, on the particular aspects of argumentation that they wished to address. For instance, Lesson 3 in Case Study 1, (an argumentation lesson) focused on selecting from a number of given statements in order to explain the fall of an object. As a consequence, during this lesson, the epistemic operations used the most were 'Justification' and 'Prompts for Justification' as students had to provide a reason for their selection of statements. Moreover, T2 seemed to use the epistemic operations of 'Prompts for Evaluation' and 'Prompts for Counter-Argument', in the argumentation lessons she taught as end-of-unit lessons (Lesson 1 and Lesson 5), which provided more opportunities for students to evaluate statements and make comparisons. The link identified between the context of the lessons and the epistemic operations that characterised these lessons is valuable in identifying and promoting those contexts that are potentially more likely to advance epistemic aspects of science. For instance, argumentation lessons as end-of-unit lessons could be used to apply and promote the role of the 'critiquer' (Ford, 2008a, 2008b), since evaluative processes seemed to be more evident in these lessons. Nevertheless, ways in which critique and evaluation can become part of everyday science teaching and learning also need to be explored. Students need to see evaluation and critique as an essential element of the process of knowledge generation if they are to grasp the epistemic nature of scientific knowledge and practices.

CONCLUSIONS AND IMPLICATIONS

The results of this study suggest that there is a developmental sequence of epistemic operations from lower-order operations such as description to higher-order operations of critique and evaluation. Thematic analysis of discursive interactions in the field of education has shown how images of science as a body of unequivocal and unquestioned knowledge is conveyed (Lemke, 1990). This study, through focusing on the nature of the teacher discourse and teacher-student interactions looked at whether the use of argumentation-based activities provides a means of transforming the dominance of IRE sequences (Initiation-Response-Evaluation) to one which demands the use of extended and higher-order reasoning by students. Although the data sample is small, the analysis provides an illustration of how the nature of classroom discourse can be transformed from providing declarative knowledge to students

and relying on IRE sequences, to a developmental sequence of epistemic operations, starting from construction, moving on to justification and then to evaluation, which may advance epistemic discourse in the science classroom. According to recent recommendations (NRC, 2007) 'students need support to learn appropriate norms and language for productive participation in the discourses of science' (p.186) and argumentation can provide this support and assist students participate productively and persuasively in the discourses of science. Students will only begin to view the epistemic practice of science as such if teachers use the full range of discourse acts, or epistemic operations, which support such a practice. As a consequence, future research into ways of developing argumentation practices in science classrooms needs to introduce teachers to the practice of argumentation and at the same time, help them develop ways of structuring their talk in order to promote epistemic discourse.

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