Teachers' Use of Critical Questions for Argument Evaluation

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Abstract: Secondary students can be taught to evaluate arguments using critical questions (CQs). Science teachers who were coached in argumentation pedagogy through a year-long professional development adopted CQs to various degrees, showing growth in confidence while illustrating challenges. Teachers who used CQs more extensively saw gains in student uptake of argument evaluation questions, and in writing. Challenges included curricular pressures and differentiating instruction for English language learners.

Major issues and significance

Argumentation is seen as central to reform of science education and to scientific practice generally, as a practice that helps scientists test their views of the world (NRC, 2012). Learning to evaluate scientific (and pseudoscientific) arguments is an important competency for students and teachers to develop. A key scaffold for argument evaluation is the use of critical questions (CQs), which are questions that normatively should be asked of various arguments, adapted by Nussbaum and Dove (2018) from Walton's argumentation schemes (see, e.g., Walton & Macagno, 2016). Teachers can use CQs such as "How good is the evidence?" to promote discourse.

Theory and method

Scientific argumentation can be defined as a process of "construction and critique" of arguments, in which competing claims to explain phenomena in nature are presented and evaluated using various criteria within a scientific community (Ford, 2015). Students and teachers can and should take part in this practice. Scholars have demonstrated that argumentation can lead to learning gains, particularly in learning complex content or in conceptual change, though additional research is needed (Asterhan & Schwarz, 2016). This study aims to strengthen claims that teachers can develop argumentative competencies, especially confidence and use of CQs.

Seven teachers participated as mentees in a 10-day intervention during the summer, followed by a full school year of professional development that included coaching by more experienced teachers, lesson observations, and monthly meetings. Data included transcripts of three video-recorded lessons per participant, exit interviews, and surveys given prior to the intervention, mid-year, and in May. Research questions were:

1. In what ways will teachers use CQs in the classroom?
2. What challenges persist in using CQs?

Findings and implications

Qualitative analysis shows different ways in which teachers' confidence and extent of use of CQs increased (see Table 1). In some cases, confidence and use were connected and mutually reinforcing. For example, one teacher

Table 1: Themes

Categories	Growth	Challenge
Teacher confidence with CQs	Use and confidence connected	Curricular pressures; timing
Effects on discourse	Student uptake of questions	Overly focused on structure
English language learners	Writing improvements	Differentiating instruction

(Deborah) grew in confidence in argument evaluation as she used the argument analysis mapping tool in lessons throughout the year. (This tool was a worksheet mapping argument components to CQs.) In her exit interview, Deborah spoke of avoiding second-guessing herself. In her Quarter 2 lesson, she elicited student discourse in a whole-group discussion of moon phases. The discussion focused on argumentation vocabulary (claim, evidence, and reasoning), and Deborah tried to systematize student knowledge about evidence. However, both Deborah and the students referred to evidence in general terms that did not directly address the scientific concepts. In contrast, in a small group discussion of genetics in Quarter 4, Deborah probed student statements about evidence much more specifically, asking repeated questions about specific pieces of evidence in students' critiques. This

growth in probing questions is a desired outcome, because both teachers and students need to ask such questions in order to evaluate arguments.

Evidence also points to students taking up CQs as teachers used them more extensively in the classroom. Elissa said in her interview that she noticed a shift in Quarter 3, in which students began using CQs as a tool for argument evaluation. Backward mapping her comments onto her Quarter 3 lesson, we saw students taking up general evidence evaluation questions, similar to the CQs, in their small-group discussions. The teacher's repeated prompts to focus on good evidence may have led students to ask *why questions* of each other. In Elissa's Quarter 4 lesson on reproduction, students probed each other's answers with why questions when there was a dispute in identifying the mode of reproduction. Although specific wording of CQs presented did not appear in students' dialogues, the emphasis on argument evaluation transferred to students in both lessons.

Karen, a fifth-year teacher in a relatively affluent suburban school, showed more mixed results with regard to argumentation pedagogy and CQs specifically. Per her selected-response survey answers, Karen gained confidence in all measured areas of teaching of argumentation except her general and self-beliefs. Her open-ended survey answers showed a desire to shift toward more student engagement/agency through argumentation. The three classroom observations showed a shift toward discussion of argument structure in her final lesson, and she asked one argument evaluation question in that lesson, compared to none in the first two.

On the other hand, analysis of Karen's Quarter 4 lesson, a fishbowl debate about genetically modified organisms, shows that almost all of the argument structure questions counted can be attributed to Karen's prompting of students for counterarguments. While consideration of counterarguments is an important measure of argument strength, Karen's prompting did not use CQs. In her interview, she said she felt she did not have time to go in-depth given the curricular pressures and comparisons with her peer teachers. She also said after the third-quarter observation that although she included a graphic organizer using argumentation in students' work packets, she did not feel comfortable using it, as it took too much time. Backward mapping her exit interview onto her observed lessons showed a high count of quotations related to in-depth discussion and student agency in her Quarter 2 lesson. However, there was some confusion among students, which may account for the high counts, and Karen's answers to student questions tended to be more reflexive ("What do you think?") than argumentative. Also, a high degree of student agency and in-depth discussion were not shown in later lessons.

Another challenge reported by teacher participants in the exit interviews is adapting CQs to English language learners. Four of the seven teacher participants taught in majority-minority schools in low SES zones. Per the state demographic report, those schools' proportion of ELL students was between 30% and 40%. Differentiating instruction for ELL students was not addressed by the professional development, but CQs had an impact on some of these students, particularly regarding written arguments. Annie, a 7th-grade teacher at a predominantly Hispanic school, said in her exit interview that 85% of her full-year students showed either growth over time (81%) or mastery (4%) in an argumentative writing rubric supplied by her school administration. She documented this growth relative to "student learning goals" (SLGs), as part of the state accountability framework. In addition, Annie said the argument vee diagram, a graphic organizer containing CQs, helped her students prepare written arguments. Two other teachers in high-ELL population schools (Deborah and Henry) also reported growth in their argument-related SLGs. In addition, Elissa, who taught at a high-ELL school, reported gains in students' writing, including length and complexity of arguments.

The analysis has theoretical and practical implications: teachers who used CQs saw results in students' discourse and writing that support CQs' use as scaffolds for argumentation in science classrooms. Challenges such as timing and curricular pressures persist in developing argument evaluation as a key classroom practice, but progress can be made in developing teachers' competencies in scientific argumentation. Teachers who used CQs more extensively developed confidence in argumentation; students also learned to evaluate arguments.

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