Interdisciplinary dialogic argumentation and change in epistemic practices among science teachers

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PHD

by

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Abstract

Out-of-field (OOF) teaching, where teachers are assigned subjects outside their area of expertise, is a global educational challenge. OOF teachers lack in-depth content and pedagogical-content knowledge, negatively impacting student learning. In addition, they carry epistemic practices - ways of constructing knowledge - from their original disciplines that differ from those of their new field.

We argue that the former resources of OOF teachers can play a facilitating role rather than being disregarded, and propose a professional development (PD) approach that encourages OOF and in-field teachers to articulate their respective epistemologies and engage in interdisciplinary dialogic argumentation. The study focuses on biology and chemistry teachers assigned to teach middle-school physics. We identified epistemic differences between these subjects in our national curriculum: emphasis on deductive reasoning in physics versus a greater emphasis on mechanistic reasoning and experimental design in the way biology and chemistry are taught. These differences provide opportunities for cross-disciplinary learning and dialogue that expand the boundaries of school-physics to include diverse ways of constructing knowledge needed to address complex problems.

The study is situated within the Gateway to Physics program, a national initiative that supports middle-school physics teachers through professional learning communities, serving over 250 teachers in more than 15 communities from 2021-2024. The research aims to map the relationships between antecedents of PD activities (e.g., group composition, activity design), the type of discourse that develops among teachers (e.g., deliberative, disputative), and the enhancement of epistemic practices.

The first phase of the dissertation involved the formulation of design guidelines for PD activities that promote interdisciplinary dialogic

argumentation. We drew on recommended guidelines for dialogic argumentation and productive engagement in educational tasks such as articulating dialogic norms, attending to group arrangement, and scaffolding the argumentation process. To support interdisciplinarity and dialogue in the context of physics, where disciplinary discourse is often authoritative and promotes one canonical answer to every problem, we have developed activities that create space for more symmetric conflicts. We problematized the content of our tasks to revolve around context-rich phenomena that create situations where opposing hypotheses can be partially justified, and further synthesis is needed to reach resolution. The (expected) rival hypotheses were grounded in the different disciplinary strengths of OOF and in-field teachers.

Following this design, we conducted an in-depth analysis of teacher discourse in a dialogic PD activity. Using Actor-Network theory and the AIR model of epistemic cognition, we show how the instructional design helped shape dialogic interactions among teachers in which OOF teachers were able to resist power relations, express their views, and contribute to the formulation of arguments in physics that were not only based on disciplinary formalisms but also considered the complexity of real-world phenomena and empirical reasoning. Several studies show that dialogic argumentation contributes to cognitive development. These results show that dialogic argumentation, supported by interdisciplinarity, can enhance epistemic practices in a group.

Based on these promising results, we developed a quantitative coding tool to capture both the dialogic and epistemic aspects of teachers' discourse and to examine them across many groups. The discourse of 17 teacher triads was analyzed, including 8 heterogeneous groups of OOF and in-field teachers and 9 homogeneous groups of only OOF or only in-field teachers. The results indicate that heterogeneous groups were, on average, more successful in engaging in deliberative and epistemically-rich dialogues (with no statistical significance, though). However, success in these groups varied considerably. Further analysis led to a distinction between successful and unsuccessful

heterogeneous groups and revealed that participants in successful heterogeneous groups mostly challenged each other directly, whereas direct challenges were avoided in less deliberative groups (with statistical significance). These results show that epistemic diversity alone is not sufficient: direct cross-disciplinary critiques act as mediators for interdisciplinary deliberation.

In the final phase of this work, we analyzed several cases of teachers' classroom implementation following the PD experience. Using the boundary-crossing framework, we found that OOF teachers modified PD activities to integrate their familiar practices with the new, physics-oriented epistemic practices introduced in the PD, and used various mechanisms and boundary objects to support this integration. These findings support our conjecture that in the case of OOF teachers, successful implementation should be framed as an integration of new and former practices rather than expecting a complete change in practice.

This work offers both theoretical and practical contributions. Theoretically, it improves our understanding of the relationship between dialogic argumentation, interdisciplinarity and epistemic development. Practically, it offers a novel approach to the PD of OOF teachers that leverages epistemic diversity to improve physics and science teaching. We discuss the systemic implications of these findings.