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“These Two Worlds Are Antithetical": Epistemic Tensions in Integrating Computational Thinking in K12 Humanities and Arts

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Abstract: While advocates for interdisciplinary learning have voiced risks of separating out disciplinary learning into discrete silos, studies of contact between heterogeneous disciplinary perspectives in both pedagogical and real world professional settings point to other risks that educators may need to consider. As such, designing for interdisciplinary learning does not simply require addressing functional problems such as teacher professional learning and time in the school day, but rather implicates complex epistemological navigations that must be taken into account. This manuscript explores potential epistemic tensions between Computational Thinking (CT) and humanities and arts disciplines based on a Delphi study with experts from three humanities disciplines—language arts, social studies, and arts. We analyzed how experts talked about epistemic tensions between CT and their disciplines and how they saw possible resolutions for those tensions. Our analysis found 5 epistemic tensions: contextual reductionism, procedural reductionism, epistemic chauvinism, threats to epistemic identities, and epistemic convergence.

Introduction

There have been recent calls for the field of the Learning Sciences to attend to learning processes in contexts that cross disciplinary boundaries (Herrenkohl & Polman, 2018), such as cross-disciplinary collaborations (Edwards, 2005), interdisciplinary learning ecologies (Damşa et al., 2020) and classroom curriculum that promotes epistemic heterogeneity (Pierson, Brady, Clark & Sengupta, 2022). Simultaneously, there have been increasing efforts to overcome the way the typical school day is organized around the norm of disciplinarity by designing learning environments that directly integrate disciplines together (e.g. Finch, Moreno & Shapiro, 2021), or that help learners make connections and appreciate distinctions between disciplines (Stevens, Wineburg, Herrenkohl, & Bell, 2005). These directions of scholarship have generated important questions for the field such as how learners draw across epistemic practices as they navigate complex problems, and how learning environments can be better designed to support learners’ development of meta-epistemic fluency (Damşa et al., 2022; Stevens et al., 2005).

Yet, these questions cannot be fully answered without adequately attending to the tensions that emerge when heterogenous epistemic disciplines come into contact—tensions that can lead to missed opportunities and/or harms in the learning process. For example, in K12 classroom settings, such as the life sciences, teachers and students using epistemic approaches that map onto ‘settled’ Westernized practices (such as classifying nature into taxonomies) have actively silenced students who use epistemic perspectives that draw on non-Westernized approaches (such as viewing nature in terms of ecological relationships) (Warren, Shirin, Rosebery, Bang, & Taylor, 2020). In another example, in the context of the professional setting of public policy, data-driven cost-benefit analysis has dominated humanistic epistemologies, resulting in an elevation of values of efficiency over those of equality in policy construction (Berman, 2022). As such, considering differences across, and tensions between, epistemologies is critical for scholars and designers of interdisciplinary learning if they wish to effectively prepare students to not just address societal challenges, but avoid reinforcing them through a lack of meta-epistemic fluency.

Unfortunately, the phenomenon of epistemic tensions is understudied, and there is little guidance for educators on how to recognize epistemic tensions, and to support learners in productively navigating them. Utilizing the context of pedagogical integration of computational thinking (CT) practices (Grover & Pea, 2013) within the context of K12 language arts, social studies, and arts instruction, this manuscript presents findings from an empirical

study of expert perspectives that surfaced epistemic tensions between CT and humanities disciplines, and potential avenues for resolution of these tensions. Identifying the epistemic tensions within the context of CT integration in K12 humanities disciplines is particularly timely given growing nation-wide efforts to implement comprehensive computing education under the banner of Computer Science for All (Vogel, Santo, & Ching, 2016), which is often inclusive of efforts to integrate CT directly into the humanities (Neumann & Dion, 2021)

Methodology

Our study aims to address two research questions. RQ1: Within the context of interdisciplinary pedagogy, what potential tensions exist between epistemologies of K12 humanities disciplines—social studies, language arts, and arts—and those associated with computational thinking? RQ2: What possibilities exist for resolution of these epistemic tensions within interdisciplinary pedagogical contexts? In order to address these questions, we conducted a Delphi study (Linstone & Turoff, 1975) to utilize expert consultation as a means to gather judgments on the intersection of CT and K12 humanities disciplines, assess and compare across expert perspectives that are not currently documented in extant literature, and generate new ideas (Franklin & Hart, 2006).

We collected qualitative data from each of the 43 participating delphi experts who ranged in institutional role (10 classroom teachers, 10 instructional specialists, and 23 education researchers), focal discipline (Arts=13, Social Studies=14, and Language arts=16), and pre-existing expertise in computational thinking (21 with, and 22 without). Study data included ~26 hours of video recordings and transcribed audio of whole group and small group discussions across six delphi focus group sessions (two for each of the three focal disciplines), and 312 written annotations of varying length by experts sharing their perspectives on the potential intersection of computational thinking and their focal discipline.

We analyzed data using a coding scheme aligned with the conceptual framework of Expansive Learning (Engeström, 1987), whereby contradictions experienced within and between activity systems, in this case epistemic tensions (RQ1), become focal points for advancing beyond the current limitations of existing systems and generate previously unconsidered solutions, in this case, resolutions to said tensions (RQ2) (Engeström & Sannino, 2016).

Findings

In considering possible relationships between epistemologies of computational thinking and those associated with K12 disciplines of social studies, language arts, and arts within integrated learning, participants in our study repeatedly surfaced five epistemic tensions (Table 1), as well as three potential resolutions (Table 2).

Table 1

Epistemic tensions expressed by delphi study experts related to integration of computational thinking into humanities and arts disciplines

Tension	Definition
Contextual Reductionism	Losses of nuance, particularity, and ambiguity around, for example, historical events or pieces of literature that could result from CT's valuation of abstraction, quantification, modeling, pattern recognition, and prediction practices.
Procedural Reductionism	Problematic reduction of complex epistemic practices into sets of tractable steps. This tension was often expressed in relation to what was seen as inappropriate application of algorithmic logics to knowledge production.
Epistemic Chauvinism	Elevation of CT epistemologies at the expense of those related to a focal discipline in ways that devalue existing ways of knowing within a discipline. For example, some experts raised concerns that interdisciplinary approaches under discussion would end up foregrounding computational tools in ways that would supersede ways of knowing connected to their focal disciplinary values.

Threats to Epistemic Identities	Concerns that cultural and historical identities associated with humanities and arts epistemologies—their epistemological 'ways of being', so to speak—could be under threat during integration of computational thinking epistemologies. Some arts experts, for example, expressed concern about alienating 'art kids' who identify less with epistemologies that center logic and deductive reasoning.
Epistemic Convergence	Concerns that overlaps and similarities in epistemologies associated with CT and those of a focal discipline could lead to superficial semantic shifts and "reskinning" of existing practices, rather than substantive extensions into authentic interdisciplinary learning.

Table 2

Possible resolutions to epistemic tensions expressed by delphi study experts related to integration of computational thinking into humanities and arts disciplines

Resolution	**Definition**
Educator meta-epistemic assessment of CT applicability	Suggestions that educators actively reflect on the specific pedagogical context and associated epistemic learning goals of their core discipline in order to determine benefits and tensions of integrating CT practices into said context (e.g. a particular unit of study, particular students). In this process, educators would actively define ways in which CT might be grounded in their core disciplinary epistemology, and how to avoid integration approaches likely to result in epistemic tensions.
Student exploration of epistemic affordances and limitations of CT	Suggestions that educators highlight epistemic affordances and limitations present in integrations of CT and their core disciplinary epistemology within interdisciplinary learning settings, centering contradictions as a site of inquiry and student learning about deployment of varied epistemic practices.
Embracing epistemic pluralism	Suggestions that educators actively highlight the value of differences between CT and core disciplinary epistemologies for students, instead of shying away from them. For example, a social studies educator could use abstraction to look at patterns across historical events alongside epistemic practices of historical analysis that examine the nuance between those situations. Experts viewed combining these two perspectives as a way to new opportunities for learning.

Conclusion

As the Learning Sciences field turns its attention to designing and studying contexts that span disciplinary boundaries, fundamental questions need to be addressed such as: what kinds of epistemic tensions emerge when multiple disciplines are brought together? Further, what harms might these tensions cause? Further still, how can educators effectively design and implement interdisciplinary learning environments that support learners to productively navigate these tensions?

We see it as critical to actively attend to these issues as the field of computing education considers further work bringing its ways of knowing and doing into humanities and arts disciplines in K12 contexts. Our analysis works to put into conversation contemporary trends occurring within the computing education community that see interdisciplinary integration as a key site of implementation in K12 (Neumann & Dion, 2021; Weintrop et al., 2016) with the voices and perspectives of those that have expertise within disciplines that might be sites of integration.

More than any specific tension in and of itself, the study's findings demonstrate that the dynamics implicit in integrating computational thinking into K12 humanities and arts pedagogies are not merely limited to implementation challenges such as availability of instructional time, technology, and teacher capacity, but rather also operate on the fundamental level of epistemic commitments, identities, cultures and histories of the disciplines in question. This space of epistemic interaction between CT and existing disciplines is one that, ideally, would be

attended to *prior* to addressing more "classic" implementation challenges in classrooms and schools in order to ensure that various harms are avoided, and opportunities for interdisciplinary enhancement are centered.

While this study is limited in that it did not directly examine epistemic tensions *in situ* within interdisciplinary learning environments, we see the expert perspectives surfaced here as advancing broader scholarship on interdisciplinary learning. Especially given possible risks, consulting experts and exploring tensions that can arise during contact between disciplines provides important starting points for both future scholarship and intentional design of impactful interdisciplinary learning.

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