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Taking on "Big Problems": Spatial Scales in Youth Work at a Data Science Camp

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Abstract: Data science education (DSE) has recently gained increased attention. We present a framework for analyzing youth-authored community data science investigations and illustrate our framework with case studies demonstrating the benefits of scaffolding learners' trajectories across spatial scales. Our findings suggest that "sliding" between personal, community, and global scales supports reasoning about complex problems, offering insights for educators to support youth in tackling "big problems" and making sense of their world through data.

Introduction

In data science education, youth are increasingly encouraged to tackle "big problems" with significant implications for their communities and futures (Lemee & Blikstein, 2024). While these challenges can engage learners, they are often complex and subjective, requiring students to navigate ambiguity and draw on personal experiences (Marin et al., 2020; Taylor & Hall, 2013). As they do, some youth are more adept than others at applying data science practices to make sense of the world around them - a variability influenced by differences in motivation, problem-solving skills, and emotional resilience (Beckman & Barry, 2007; Marin et al., 2020). Drawing on spatially informed mathematics education (Rubel et al., 2016, 2017) and mobile learning (Marin et al., 2020), we developed a framework to examine how learners engage with data science inquiry projects across three spatial scales: *personal, community,* and *global*. This framework allows us to interpret how students connect data science concepts to immediate, local, and broader global issues, supporting educators in scaffolding youth engagement with complex, real-world issues.

Methods

We analyze posters created by 44 youth, 11 to 12 years old, who participated in three sessions of a week-long data science camp in 2024 at a science museum in a major metropolitan area in the Northeast US. During this camp, the youth developed a research project related to a question they had about spaces in their community. Campers received a variety of environmental sensors to take home with them as they collected data in spaces of their choosing. Camp staff supported campers in defining a research question, devising a data collection plan, collecting data using sensors connected to a data logging board, analyzing their findings, and presenting them to their peers and families in a poster session.

Our analysis examined the posters created by campers across these three camps, focusing on the *Research Questions*, *Motivations*, and *Data Collection Plans* articulated within these artifacts. Posters missing information in any of these areas were excluded, resulting in a sample of 19 posters. Guided by our framework, we analyzed each poster to see how learners engaged with *personal, community,* and *global* spatial scales. The *personal scale* captures the learners' immediate space (e.g., "my room" or "the kitchen"), the *community scale* includes spaces beyond the home within a bounded geographic area (e.g., neighborhood or town), and the *global scale* represents broader, interconnected spaces (e.g., "the world" or "everyone"). We define *community scale a*s outside of the learner's home space but within a *bounded* geographic distance, in contrast to social communities which can be geographically expansive.

Findings

As campers used data science to explore topics of interest in their communities, we observed that the practice of moving between these different scales, mentally and physically, seemed to support their reasoning and engagement with "big problems." Of the 19 posters, 12 (~63%) stayed exclusively within either the personal or the community scale, four (~21%) moved between two scales, and three (~16%) moved between all three scales (See Table 1). Below, we detail two posters that investigate air quality: one representing a camper's focus on a single scale (personal) and another showcasing a camper sliding across all three scales (personal, global, and community). These cases demonstrate the benefits of supporting learners' sliding between scales as they conduct data science investigations into "big problems."

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Table 1
Count of Combination of Scales Represented in Posters

	Personal Only	Community Only	Personal, Community	Personal, Global	Community, Global	Personal, Community, Global
Count of Posters	4 (~21%)	8 (~42%)	2 (~11%)	1 (~5%)	1 (~5%)	3 (~16%)

Note: There were no posters that represented only the global scale.

Case 1: Staying within the personal scale

Kasey was concerned about the cleanliness of her room ("I want to avoid dust … so I don't get sick") and set out to understand how dust particles circulate in her bedroom (research question: "How much dust is on my bed?"). This *personal* motivation set the foundation for her project. To investigate, Kasey used a PM2.5 sensor to measure the amount of dust on her bed while the AC was running, as well as in her parents' room, and the living room. By recording dust levels across spaces, Kasey hoped to understand where dust was most concentrated, trace dust patterns, and locate any spikes. Her initial curiosity about her immediate environment led her to broader, more open-ended questions: "Why is dust coming out of my AC?" and "Can I use this information for the future?" These speculative questions showed how her exploration evolved from a purely personal inquiry to a foundation for thinking more broadly about indoor environmental quality. Her study illustrates how a "small," personal question can spark meaningful explorations, driving her to ask more questions that matter to her life.

Case 2: Sliding between scales

Dylan noticed that "walking around my house, it did not smell really good," which he attributed to the nearby factories. This *personal* concern for the quality of air in his home motivated him to explore a *community*-scale issue of the air quality impact of factories and the potential health consequences of breathing toxic air for both himself and "everyone in [his] community." He measured the air quality at various locations around his community using a PM2.5 sensor, traveling to areas with factories and comparing the air quality there to the air quality in a neighborhood park. From its beginnings in the personal and community scales, Dylan's project slid again into the *global* scale when he asked the broader, "How do factories affect air quality and how can we stop it?" This "big" research question investigates the health impacts of industrialization and how to stop its negative health outcomes. As he reasons with how to conduct his investigation, Dylan slides back into the *community* scale, seeking out nearby spaces that provide comparison points for air quality: near a factory and in a park. We argue that sliding back to the community scale was crucial for Dylan's ability to engage meaningfully with his big question, as it brings the question back into a space that Dylan can see and interact with, making it more approachable, both cognitively and physically.

Conclusions

By focusing on a *personal* scope, Kasey tackled a manageable, actionable question, giving her a sense of achievement and ownership over her data. Her work highlights the potential of personal-scale investigations in building familiarity with the data science process without the daunting pressure of addressing broader complex issues. This case illustrates how a focus on *one scale* can be an effective entry point for learners to build confidence and skills that feel accessible and meaningful. In contrast, Dylan's work demonstrates the value of sliding between the *personal*, *global*, and *community* scales to engage with a "big problem" in his community, helping him both practice the data science process and begin to make sense of the world around him. While he was unable to fully answer his question and he did not address how to stop negative health impacts, his work showed a consistent throughline and demonstrated his ability to use data science to investigate a complex problem. Together, these case studies show that encouraging an approach of sliding between the personal, community, and global spatial scales in youth's data science processes can support their ability to engage with data-inspired problems.

Navigating across multiple scales is intrinsic to DSE. Offering students frameworks and facilitation to transition between scales can ensure that their research topics remain personally relevant, and the data analysis is kept coherent. As students go from a few data points to thousands, the complexity of the data work increases, but so does the impact and generalizability of the work. Our cases show the value of creating learning environments that allow one to explore scales that feel meaningful while building opportunities to connect across scales when appropriate. Educators might consider how to design scaffolding that both respects individual entry points and expands youth's capacity to engage with broader challenges over time.

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