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Mapping Organizational Infrastructure: Semiotic Cluster Analysis in a School District Change Initiative

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Abstract: Designing for organizational change has become an increasingly important goal in the learning sciences. To do so, we must develop processes that highlight organizational infrastructures that inform both research and design. In this paper, we share our experience conducting semiotic cluster analysis to map organizational infrastructures within a research practice partnership. We describe how semiotic analysis attuned us to relationships that speak to organizational factors influencing the objectives of our RPP. Then, we share our process for generating design conjectures that attend to the organizational infrastructure identified through semiotic analysis. Our work provides an example of tracing surface level observations to core organizational needs.

Introduction

Designing for partners' capacity to create organizational change within research practice partnerships (RPPs) has emerged as a critical issue in the learning sciences (Farrell et al., 2022). Doing so requires understanding how a partner's organizational context translates to important infrastructuring needs that can be designed to foster change (Penuel, 2019). The collaborative and iterative effort required to understand the relationship between partners' voiced needs and the broader organizational context requires careful attention to what matters most to a partner (Campos et al., 2024). However, one cannot simply attend to all needs that a partner communicates. Instead, our research group is exploring different ways to identify which observations point to the most critical needs of the partner organization, and then translate these needs into opportunities for design and research. In the case of large-scale partnerships, like those with urban school districts, there is a need to develop processes that allow us to collect experiences from a wide array of stakeholders, identify how key observations emerge from organizational infrastructures, and translate insights into actionable design conjectures that attend to our partner's needs (Chen, 2024).

In this paper, we demonstrate how an analysis approach – **semiotic cluster analysis (SCA)** – can help connect individual partner observations to underlying organizational needs. From the context of an ongoing RPP, we describe how semiotic analysis attuned us to the ways educators discuss and make decisions with data. Then, we share select design opportunities that emerged from our analysis which inform our current implementation cycle. This work contributes to our understanding of designing for the capacity to generate organizational change within the context of an RPP, and demonstrates how researchers may use SCA to identify actionable design conjectures that attend to partners' needs.

Infrastructuring for organizational change

DBIR emphasizes collaboration with multiple stakeholders to address practical problems and to build capacity for sustainable change (Penuel & Potvin, 2021). Many learning scientists situate DBIR within RPPs to facilitate long-term cooperation between researchers and community partners. Through these collaborations, researchers and partners work on problems of practice faced by partner organizations (Coburn et al., 2013). Recently, learning scientists designing to develop capacity for organizational change have turned toward theories of "infrastructuring" that engage with organizations' infrastructure, or how the practices and norms of individuals emerge from norms that make up organizations (e.g. Hladik et al., 2023). These theories acknowledge that cultivating change necessitates designing within and against existing conditions that form an organization's infrastructure (Penuel, 2019). How scholars attune to the organizational features that are salient to infrastructuring work varies based on the scale and nature of unique partnerships. This challenge suggests a need for additional infrastructuring tools that can be applied to a wide variety of partnerships (Chen, 2024). Our work contributes a research process for infrastructuring in RPPs. We leverage SCA to identify key organizational infrastructures that shape educator data practices and describe how we use these insights to inform ongoing design research.

Methods

Context of study

This work stems from a multi-year DBIR project nested within an RPP between a university research lab and a large urban school district. For anonymity, we refer to this district as the Manzanilla school district. Prior to the initiation of the partnership, Manzanilla enacted a change effort to shift teachers' focus away from student performance on traditional assessments, like state standardized assessments. The district hoped for teachers to recognize skills that go unaccounted for in traditional assessments, such as collaboration, creativity, critical thinking, communication, and character (5Cs). For the first several years of the change effort, Manzanilla implemented Microsoft Word document-based performance task assessments that introduced a massive workload of analysis and progress tracking for teachers. Our partnership organized around this problem and set out to co-design a system that could collect student reflections and deliver actionable information to teachers, with minimal impact on their workflow. These formative assessment goals are what education researchers call practical measures (Ing et al., 2021; Takahashi et al., 2022). Together we designed student reflection questions that elicit student narratives. For example, students may be asked to recall a time they encountered a culture or background that differed from theirs and to share what they learned. Our pilot system leveraged a large language model (GPT-3.5) to synthesize student reflections and deliver analytics about students' 5C skills and cultural strengths (Gonzalez et al., 2006). We piloted a prototype of this system with 1,000 teachers and 16,000 students.

Data sources and analysis

We conducted 14 focus group sessions with over 100 educators across Manzanilla. The majority of participants were classroom teachers, but participants also included administrators, education specialists, curriculum specialists, and community coordinators. During focus groups, participants were asked to share ideas, questions, and critical perspectives related to the district's organizational change initiative, our prototype design, how they could use student data produced from the AI system, and their perspectives on AI use in their practice. Focus group data was analyzed iteratively and collaboratively. First, members of the research team generated inductive memos containing noticings and illustrative excerpts from interview transcripts. The team clustered memos into exploratory themes and developed a qualitative codebook. Next, the research team collaboratively coded each focus group transcript using Dedoose (Version 9.0.17). The codebook includes parent codes such as "teacher's use of data", and sub codes such as "inform lesson planning" and "understand student experiences". Authors used the results of this coding to identify 147 excerpts of educators discussing data or the district initiative.

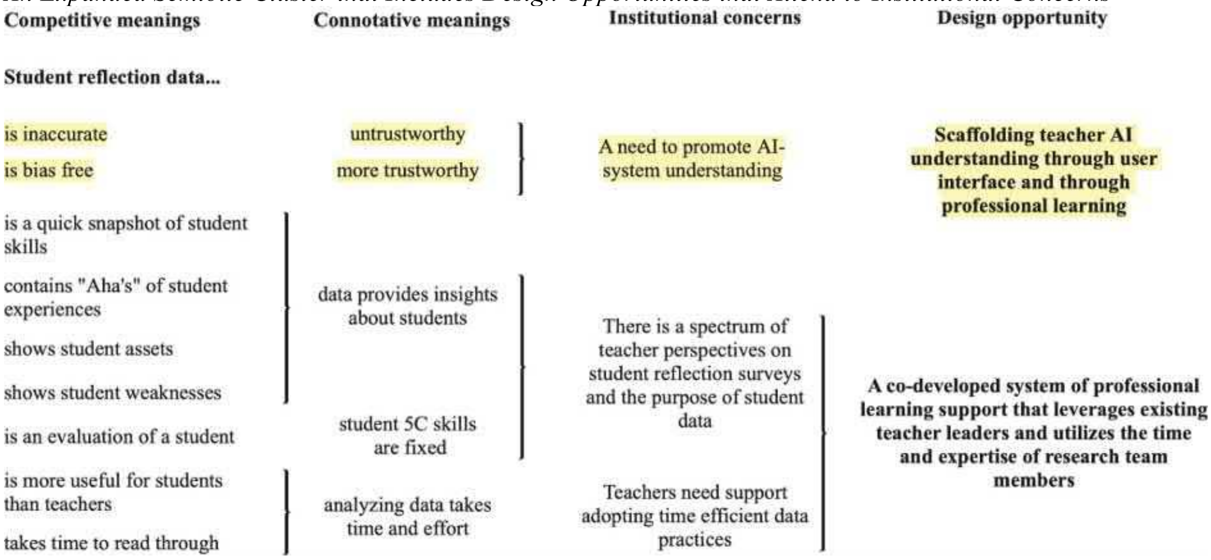
From here, we began SCA (Manning, 1987). SCA is an ethnomethodological approach established to highlight relationships within organizations that may go unnoticed (Feldman, 1994). We use it here due to our interest in examining how the teachers' data practices emerge from the underlying infrastructure of Manzanilla and our RPP. Semiotics is rooted in the study of signs and signification (Eco, 1979; Vannini, 2007). Signs refer to the words, behaviors, and objects that carry meaning to a community (Eco, 1979). Signification concerns the processes by which signs acquire meaning (Barley, 1983). Semiotics assumes that a community's signs are related to its underlying structure (Feldman, 1994). Our team identified topics that stood out to them (e.g. student reflection data) and read through our selection of focal excerpts to identify and pull out the competing meanings that educators used to describe that topic (e.g. "Aha's of student experience" and "shows student weaknesses"). We then organized competitive meanings through two semiotic mechanisms: metonymy and opposition. Metonymy describes a relationship between signs that fall within the same domain. For example, a red light and stop sign share a metonymic relationship, each signifying that traffic must stop. Opposition describes a relationship where meaning is derived from a dichotomous relationship between signs. For example, a red light and a green light share an oppositional relationship, where significance is derived from being the opposite of the other, stop or go. Next, in an adjacent column we listed their connotative meanings, connotative meanings sought to answer the question: *"What does it mean when an educator in Manzanilla talks about [salient topic] as [competitive meaning]?"* Next, we figured and listed "institutional concerns" that explain the relation between competing and connotative meanings. These institutional concerns emerged from a triangulation of focus group data, field notes from two and a half years of meetings with district partners, and author team perspectives on the RPP itself. These institutional concerns were refined over a series of three consensus meetings, where authors met and talked through the logic of their semiotic clusters. During consensus meetings, authors discussed how connections between observations in focus group data, interactions with Manzanilla members, and their existing knowledge about Manzanilla informed the creation of the semiotic cluster. The final step in constructing these semiotic clusters was to collectively conceive "design opportunities" that attended to the relation between institutional concerns, and the connotative meanings expressed by educators in Manzanilla. In the formation of design opportunities, the authorship team pushed each other to consider both technological and non-technological design solutions. We present one set of results from this analysis below

Findings

A focus for our RPP is shifting how educators think about and use student reflection data produced by our AI system. This data takes multiple forms, consisting of transcripts of student reflections, AI syntheses of those reflections, and data visualizations depicting metrics of student progress for each 5C skill. While becoming familiar with our focus group dataset through a round of analytical memoing, we found that teachers attuned to various aspects of student reflection data, noticing and discussing the data in different ways. Thus, we constructed a semiotic cluster diagram (Figure 1) in an effort to understand how teachers discuss student reflection data and what infrastructures within Manzanilla those ways of discussing data emerge from. Due to space constraints, in the following section we share how we constructed one thread of our full semiotic cluster diagram (highlighted below). We will describe how we assembled competitive meanings, generated connotative meanings, derived institutional concerns, and developed design opportunities by linking observations in data and knowledge built from engaging in an RPP.

Developing semiotic clusters for infrastructuring

Figure 1
An Expanded Semiotic Cluster that Includes Design Opportunities that Attend to Institutional Concerns



We began SCA by gathering all of the ways teachers signified our focal topic “student reflection data” and listed them in the left most column “competitive meanings.” We then organized each competitive meaning, grouping them together based on metonymic or oppositional relationships The highlighted pair of competitive meanings in this semiotic cluster, *is inaccurate* and *is bias-free* are grouped together due to their oppositional relationship. This dichotomy in the way teachers signify “student reflection data” is significant to us due to our interest in teachers’ data attribution, or how they understand the root causes of data (Bertrand & Marsh 2015). Teachers using the meaning – *is inaccurate* – cited concerns around using AI to synthesize student reflection data. These teachers recalled anecdotes about specific instances where they encountered inaccurate data, like one teacher who shared with us a story of how one of her students seemed to be doing very well in a number of 5C skills, but when they went to read the student’s reflections, it became clear that the student had copy-and-pasted lengthy excerpts generated from ChatGPT that were unrelated to the reflection questions. To these teachers, inaccuracy reduced the data’s usefulness and decreased the teachers’ desire to engage with AI-produced data. *Is bias-free* represents statements from teachers that expressed trust in the AI-generated data because they perceived the AI to be absent of biases that may incorrectly raise or lower a student’s skill development rating. To some teachers, this meant removing biases they held related to their perceptions of students' performance. For example, one teacher told us, *“Piggybacking off the first statement, I like the idea that it does remove the bias of teachers, because as much as we sometimes try not to have that it's just, it's there, you know, I know my students who are, who are top performers, and I'm just going to often sometimes assumed that they are in every area, right.”* For other teachers, having AI-generated student reflection data would rectify instances of students self-rating themselves too high or too low in 5C skill development. To these teachers, AI-generated student reflection data was more objective. We placed *is inaccurate* and *is bias-free* beside each other on our semiotic cluster due to their oppositional relationship.

We figured that when sharing statements that aligned with *is inaccurate* or *is bias-free,* teachers expressed degrees of trust in data. *Is inaccurate* statements expressed distrust in AI-generated data. These teachers did not believe AI was capable of accurately processing student reflection responses and rating students in the same way they would. *Is bias-free* statements expressed a high degree of trust, going so far as to believe that AI was capable of generating objective data that could be even more accurate than they could produce.

To identify an institutional concern that oppositional perceptions of trust in AI could emerge from, we considered that generative AI is a new technology and that teachers' experience with AI varied greatly. Teachers do not have access to the exact ways our AI system works and produces data, nor can they see how large language model systems like ChatGPT operate. For these reasons, we hypothesized that considerable distrust or trust in our AI-produced data emerges from a need to support teachers' AI-system understanding.

Generating design opportunities rooted in infrastructure

As design-based implementation researchers, we began to see institutional concerns as opportunities for future design. We extended the traditional semiotic cluster diagram to include design opportunities that could attend directly to the institutional concerns we identified. To address the highlighted concern, "a need to support the development of teacher AI-system understanding", we were drawn toward both technical and non-technical design opportunities. We conjecture that scaffolding teachers' interactions with our AI system may support the development of deeper understanding of our system. In the technical domain, we are instituting user interface (UI) features that signify that AI analysis is meant to provide actionable insights rather than present facts. We use terms like "guesstimate" to characterize results from AI analyses to encourage teachers to question and build off of AI results rather than interpret them as something that is either right or wrong. Additionally, we imagine future iterations of our AI system would include interfaces that explain the ways we use AI to generate student data. We could add functionality that allows teachers to agree with, disagree with, and modify AI-generated information. In the non-technical domain, AI-system understanding informed the development of our professional learning protocols. To support AI-system understanding, we designed protocols that encourage 5C coaches and members of our research team to assist teachers in making sense of AI "guesstimates" and using AI generated data to build deeper understanding of students' assets.

Discussion

This study aimed to explore how researchers may employ SCA within an RPP to identify key organizational infrastructures and develop design conjectures that attend to needs in a large urban school district. By integrating SCA into the design process, we identified three key organizational features that shape the ways educators think and talk about data. We then developed design opportunities that align with the change initiative central to our RPP. Our findings represent a process for relating qualitative data to the infrastructure of an organization and developing design conjectures that attend directly to our partners' needs.

This work contributes to the emerging body of literature on building capacity for organizational change within the learning sciences. Specifically, our work demonstrates the potential of SCA as a research process for identifying and attending to organizational infrastructures in educational change initiatives. We see the utility of this method in the collaborative and iterative steps necessary to construct the semiotic cluster. Generating competitive meanings takes discussions about what in the data appeared most important and why. Moving to connotative meaning necessitates reflection on the broader organizational context. Developing institutional concerns takes reflection on organizational context and broader factors that shape how individuals experience RPP change initiatives. At each stage of this process, researchers and designers unpack their own understanding of data and organizational context, collaboratively developing a shared understanding of infrastructures to potentially design. Beyond the domain of RPPs, we add onto the work of learning scientists who have contributed methods for mapping design narratives (e.g. Hoadley, 2002) and developing conjectures for learning and design (Lee et al., 2022; Sandoval, 2014). Our research team views SCA as a process that illuminates the threads between individuals' experiences and organizational structures. Weaving these insights into design research positions learning scientists to develop conjectures that attend directly to the needs of learners.

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