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"Wait! Why is everyone connected to mine?!": Contextualizing Rule Breaking as a Design Affordance

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Abstract: This paper looks at a network visualization software and a middle school activity to explore how design affordances, and youth agency intersect in learning. Despite equitable design intentions through limiting students to three connections in the network, some students exceeded that rule, producing larger nodes that drew attention to rule-breaking. Findings show how technical affordances simultaneously intersect with rule breaking, and youth agency and expression, suggesting that even well-intentioned lesson designs can constrain youth agency and participation. By integrating literature on design justice and network visualization, these case studies reveal how data representations not only mediate participation, but also takes into consideration youth agency constraints. Youth agency emphasizes the importance of youth participation, and meaning making of the world around them. This study calls for justice-centered reflexive design that anticipates and honors student agency.

Introduction

Design in the learning sciences is never neutral; it encodes particular values and privileges some forms of participation over others (Philip et al., 2018; Penuel, 2019). What may appear as technical or pedagogical choices can potentially be deeply political, as they determine whose knowledge, identities, and ways of participating are recognized and valued (Costanza-Chock, 2020). Network visualization activities are a power tool for building data literacy and supporting critical inquiry in both STEM and humanities contexts (Wilkerson & Polman, 2020; Wilkerson & Rivero, 2020; Craig et al., 2021; Zhou et al., 2024). However, as with any tool or technology, they carry assumptions about representation, visibility, and connection. As a field, it is valuable to examine the tools we use to conduct research because if we don't, there is a risk of reproducing inequities in learning if it is left unchecked (Costanza-Chock, 2020). This paper examines the tensions that emerged in a network visualization activity with middle school learners in an English Language Arts class. The research team constrained students to each contributing to the network equally in an effort to end up with a network in which each student's node was the same size. However, no design can ever predict exactly how learners will respond and behave and, in this case, the combination of pedagogy, tool, activity, and student agency revealed features of the tool and activity design that the authors feel are important to understand. Therefore, *this paper is an exploration of design-centered case studies that gives insight on navigating the intersection of design affordances and student agency and participation*.

Theoretical framework and literature review

Design justice requires making explicit values that are encoded with tools, activities, and pedagogical choices (Costanza-Chock, 2020). Affordances refer to a tool's properties that shape the possible ways a user can engage with it, highlighting the relationship nature of design between users and technologies (Interaction Design Foundation, 2019), and highlights the ways that people learn by engaging in activities (Greeno & Engeström, 2006). These affordances both constrain and enable particular actions, ways of knowing, and modes of participation (Costanza-Chock, 2020). From a sociocultural perspective (Greeno et al., 1996), where learning and knowledge are seen in social action, this means that the affordances of technology are both mechanical and cultural; culture influences what affordances are available and technology itself is laden with the biases of the culture that created it (Gresalfi, 2018; Taylor, 2017; Greeno et al., 1996). In the learning sciences, scholars have emphasized that design is a moral and political act, shaping who gets to participate, whose identities are affirmed, and which epistemologies are legitimized (Philips et al., 2018; McWilliams, 2016). Therefore, understanding design as value-laden also draws attention to the importance of critically interrogating whose values become

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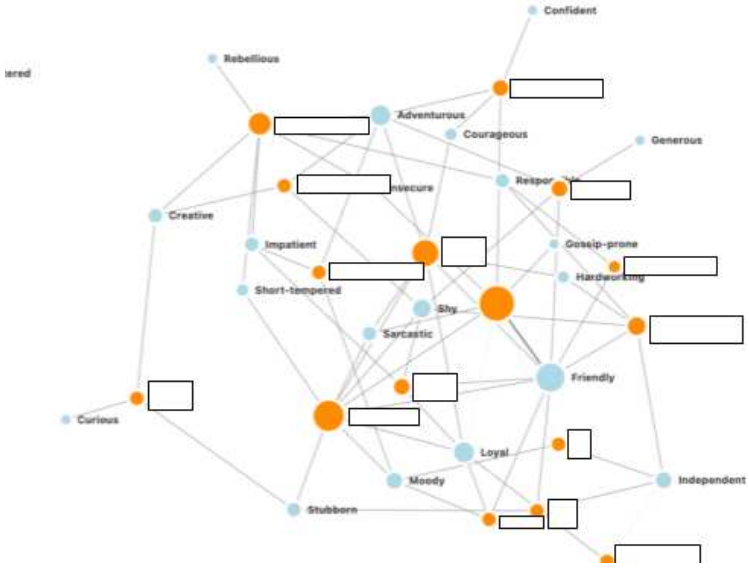
encoded in our designs, and how these values can potentially intersect with broader inequalities (Costanza-Chock, 2020).

In their most basic form, network visualizations are a collection of nodes (circles that represent various entities, objects, or "things" in a network), and edges (lines that represent connections between nodes) (Craig et al., 2021). Network visualizations serve as a powerful learning tool by representing various datasets as networks of interconnected nodes and edges, providing a visualization of the various relationships of variables (Parker et al., 2025). Together, these node-edge pairs create a structural representation that emphasizes relationality and allows learners to see not just individual elements but the broader system in which those elements are embedded (Steinberg et al., 2025). This approach can foster a deeper understanding of the complexities inherent in real-world data by providing a visual representation that demonstrates interconnectedness (Parker et al., 2025). In this study, students engaged in creating a network visualization using Net.Create (Steinberg et al., 2025). As students add nodes and edges, Net.Create dynamically recalculates degree centrality, the number of connections a node has, and automatically resizes nodes to reflect their relative importance or influence (Craig et al., 2021). Larger nodes are drawn toward the network's center, while less connected nodes drift outward, visually communicating power and visibility within the system (Craig et al., 2021). The force-directed layout models network relationships as gravitational pulls helping students' reason about individual significance within collective structures (Craig et al., 2021). When new edges are added, the entire visualization subtly repositions in real-time, making visible how incremental changes reshape the network for all participants. This responsiveness invites students to notice and question how new data shifts relationships, fostering dialogue about influence and centrality. By observing how small, low-degree nodes connected to central ones are pulled towards the middle, learner can explore how implicit and explicit power operates in complex systems (Craig et al., 2021). Ultimately, network visualizations can be designed to invite learners to interrogate visibility, power, and participation, both in data representations and in the social worlds they find themselves living in.

We position network visualizations as tools through with youth can explore their identities and social worlds (Steinberg et al., 2025). From a learning sciences perspective, peer networks act as social contexts for identity development, enabling or constraining how youth express themselves and are recognized by others (Kindermann & Gest, 2009; Santos et al., 2008). Scholars in the learning sciences emphasizes that voice is not an individual entity but emerges in relation to power, recognition, and participation within communities (Bang & Vossoughi, 2016).

Figure 1

A Collaborative Class Network that shows Node-Size Variance (Student Names are Redacted)



Methodology

This work is part of a multi-year design-based research study (Craig et al., 2021), in which we have partnered with middle schools in a public school district in the rural, southeastern United States. In this particular study, the research team focuses on our collaboration with two sixth grade English teachers and two classes that spanned over two days in the fall 2024 semester. All together, sixty-five students were consented to participate in this study. Both teachers worked together with the research team to co-design an ELA lesson that utilized network

visualization and was also in line with content and standards, creating an activity called "Dossier Confidential: Target Character Analysis." In this activity, students wrote an anonymous paragraph that included three traits about themselves and were then asked to input these same three traits into a shared class Net.Create network visualization (see Figure 1). Students connected themselves to existing trait nodes. Their teacher passed out paragraphs so each student got a dossier that was not their own. Students then utilized the traits written in their paragraph, as well as filter features (a Net.Create feature that allows users to manipulate how their data is displayed within a network, hiding or highlighting certain node or edge types), node and edge tables (a table that allows users to sort and view nodes and edges by their attributes in their non-networked form), and the entire network itself to identify the classmate who had written the anonymous paragraph. Once students had a hypothesis about who the paragraph belonged to, they confirmed their inference with their teacher. The goal was to help students see how information is embedded in a text, introducing character traits and text-evidence in an ELA context, and how these can be re-visualized in powerful ways.

In each classroom, a GoPro was placed on two tables of consented students in each of the two periods (resulting in 4 total focal groups) to capture video data. Additional data sources included the network visualizations. The authors content logged the data, looking at learners' interactions with the tool and for evidence of mediation by the tool, as well as instances of learner agency. A theme of interest that arose looked at rule breaking, how it connected to the design, and how the design affordances of the network and activity played a role. This led us to consider design justice as a framework that guided our thematic analysis.

Findings

Our analysis demonstrates that network visualizations have the power to magnify, highlight, or make salient certain features of a design. The activity was designed with the intention that each participant would make exactly three connections to three specific traits. Part of the design was to ask students to do this in order to create a 'level playing field', one where no student had a larger node than any other. However, in practice, several students did not follow the directions of the classroom teacher by creating more or less than three edges or by connecting to other people instead of to trait nodes (often both). This resulted in nodes that were larger (or, in one case, smaller) than the majority of their peers' nodes. Larger nodes have a visual distinctness which led learners to focus on them which transitively brought an increased focus on the behaviors that led to different node sizes. Here, the impact of not following instructions was magnified unintentionally by the network.

During the lesson, a research team member informally asked learners, "what was surprising about the data?" S1 responded, "a lot of people added more than three", immediately focusing on the fact that some of their classmates had added more than three connections. This noticing is accurate, but also not directly related to the task the students were assigned. Rule-breaking is common behavior and was expected by the design, but in this case the fact that rule-breaking occurred became salient to the participants in a way that influenced how they participated in the activity. Rather than looking at the intended elements of the network visualization software (i.e. tables of nodes and edges), some students were focused on how their peers did not follow the directions of only making three connections. When asked by researchers informally during the activity, "what [trait] node would describe people who connected to more than three?" S2 responded that they were "not listening," "disrespectful," and "impatient." These negative associations have the potential to create tension in the setting of a collaborative activity. S2 is one case, as they come to realize that one of the "disrespectful" classmates they had identified earlier, was, in fact, their own node. In the excerpt below, S2 realizes that one of the larger nodes, one with more than three connections, is their own node. S2 expresses confusion because they personally only made three connections.

S3: why are you connected to everything?

S2: oh no, I'm not connected to everything. Everybody's connecting to mine. Wait! Why is everybody connected to mine?! Oh... She's a big ol' circle. [S6] is connected to me. [S7] is connected to me. Why is [S7] is connected to me? How do I deconnect?

S1: how are you connected to [S7]?

S2: I don't knooooowww

Here, S2 realizes that connection classmates made to their node are visually indistinguishable from connections S2 made. It was only upon investigating the connections themselves (clicking on a node and viewing the directionality of its connections) that this difference becomes apparent. This is interesting in the present discussion of the salience of rule-breaking because S2 was one of the students that had earlier voiced displeasure with the fact some classmates had broken the rules by having more than 3 connections. This realization made S2 one of

the ‘disrespectful’ students even though S2 personally did not break the rules. S2's node was only larger because others had made connections to their node without permission.

Discussion and future work

In the learning sciences, this case highlights the interplay between design and youth agency. Despite careful anticipation of student actions, unplanned features emerged as youth exercised autonomy by creating, connecting, and experimenting with Net.Create in ways that the designers did not predict. Students’ deviations from the original task design could be seen as exercises in youth agency. This would align with Bang & Vossoughi (2016) where learning environments are seen as co-constructed spaces where design and participation are mutually constructed. Rather than treating these moments as instructional or design failures, they can be understood as opportunities to study how agency and participation emerge in tension with design constraints (Greeno & Engeström, 2006). Students’ actions may be seen as disruptive by their peers, but could also be viewed through the lenses of an expression of agency within a systems that constrained their choices and participation with the tool. This emergent phenomenon where students connected beyond their pre-determined limits demonstrates that agency often surfaces in the gaps (Gutierrez, 2008). The overlap between design tensions and social structures, where learners test, resist, and reinterpret boundaries and constraints that are set before them, potentially can create a space of boundary crossing (Coburn & Penuel, 2016). This interplay between structure and autonomy calls for designs that anticipate, not eliminate, emergence of student agency.

Moving towards future research, rather than treating these moments as failures or distractions from learning, they should be seen as providing us with an opportunity for reflexive redesigning. A justice-centered approach to design research (Costanza-Chock, 2020) would not only consider these emergent dynamics but also ask us why they occurred and how to adapt the design to honor autonomy while decreasing inequities. In this sense, these findings extend beyond design-based learning theory by illustrating that justice in design is not a fixed outcome of equitable intentions, but an ongoing negotiated practice. The unanticipated emergence of larger nodes was not a design failure, but a moment of learning for the designers to question how power, visibility, and agency become entangled in network visualizations and data representations.

This dynamics illustrates the dual nature of design affordances where it can both empower and constrain. Designs encode values and distributes power (Costanza-Chock, 2020). The lesson was designed to prevent inequities, based on the research team’s understanding of Net.Create’s affordances (its ability to enlarge nodes that had more connections) (Craig et al., 2021). However, these choices unintentionally made rule breaking more salient. This magnification shaped how students interpreted both the activity and each other, as they made moral and affective judgments such as “not listening,” or “disrespectful” based on the network’s final look and design. These reactions remind us that emotion and judgment are integral to disciplinary learning (Jaber & Hammer, 2016). When students experience confusion, frustration, or feelings of disrespect, they are epistemic indicators that shape how learners engage with a task and each other. In this case, emotions became entangled with perceptions of fairness and belonging and raised questions about how our design decisions can unintentionally reinforce hierarchies within a peer network. The emotional response of confusion, frustration, and judgment observed in this study highlights that data representations are not neutral mirrors of participation, but they mediate how students interpret one another’s actions, identities, and intentions.

Conclusion

The first step of praxis is to examine and reveal the structures and practices that support and enable injustice and bias to flourish; this study contributes to ongoing discussion of design justice in the learning sciences by revealing such a potential. Network visualization tools, like any tool, do not simply represent social worlds, but participate in their construction as active mediators, and as justice-minded researchers we must be aware of this when designing around these tools. Attending to how social hierarchies, and concepts of popularity, and identity performances interact with data representations can help educators and designers create more reflexive activities that recognize students’ emotional and social investments as central to their learning, as well as their exploratory self-expression and agency. Future work might engage students as co-designers in reflecting on this visibility, fairness, and agency, ensuring that our tools and pedagogies not only model networks of data, but also cultivate networks of care, equity, and belonging.

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