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Leveraging Cultural Forms in Human-Centered Learning Analytics Design

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Abstract

In this article, we offer theory-grounded narratives of a 4-year participatory design process of a Learning Analytics tool with K-12 educators. We describe how we *design-in-partnership* by leveraging educators' routines, values, and cultural representations into the designs of digital dashboards. We make our long-term reasoning visible by reflecting upon how design decisions were made, discuss key tensions, and analyze to what extent the developed tools were taken up in practice. Through thick design narratives, we reflect upon how cultural forms — recognizable cultural constructs that might cue and facilitate specific activities — were identified among educators and informed the design of a dashboard. We then examined the extent to which the designed tool supported coaches and teachers to engage in Generative Uncertainty, an interpretive stance in which educators manifest productive inquiries towards data. Our analysis highlights that attuning to cultural forms is a valuable first step but not enough towards designing LA tools for systems in ways that fit institutionalized practices, challenge instrumental uses, and spur productive inquiry. We conclude by offering two key criteria for making culturally-grounded design decisions in the context of long-term partnerships.

Keywords: learning analytics, participatory design, cultural forms, research-practice partnerships

Structured practitioner notes

What is already known about this topic:

- Participatory design can invite stakeholders to directly inform the creation of LA artifacts that fit their needs, context, and cultural markers.

What this paper adds:

- Cultural forms can be identified and leveraged in the design of LA tools.
- HCLA scholars ought to design for *systems* — the complex body of organizational routines, cultural practices and interactions among multiple stakeholders — and not just for *users*.

Implications for practice:

- Leveraging cultural forms in LA needs to be accompanied by a critical view of which practices, behaviors, values, and structures are suggested by such forms.
- Designing features that are easy to use, are associated with concrete tasks, and fit into existing cultural practices are three criteria for embedding cultural forms into LA design.

1. Introduction

A central tenet of human-centered learning analytics (HCLA, Buckingham Shum et al., 2019) is that design is intended to align the creation of LA with existing practices and intended uses of diverse stakeholders (Authors, 2019). Although researchers may collect evidence of whether or not dashboards or other tools work the way they are designed for, it may not be possible to draw reasoned conclusions about why and under what circumstances these tools work. One way for going beyond simple "what happened" types of analysis is to create the necessary vocabulary to describe the decisions and criteria that might make or break the adoption and use of a tool.

In this article, we describe how we leveraged *cultural forms* — recognizable cultural constructs that might cue and facilitate specific activities (Horn, 2018; Saxe, 1999) — to make decisions during the design processes and guide analyses of how the designed tools were adopted in the wild. We report from a multiyear participatory design of a dashboard with K-12 teachers and their instructional coaches, experienced educators mentoring teachers in pedagogical practices. During the course of this project, we designed dashboards that displayed students' perceptions of mathematics instruction to provide actionable insights for educators to improve their practices. Our work took place in a network of research practice partnerships (RPPs, Krumm et al., 2022), long-term partnerships between researchers and educators in three school districts to improve middle-grades mathematics instruction. Our design process was grounded in participatory design (PD, Bødker et al., 2022) and design-based research (DBR, Authors, 2022), as long-term efforts that value mutual participation of researchers and practitioners in the design and enactment of LA tools. Through design narratives that capture the history and development of designed artifacts (Hoadley, 2002), we address the following research question: **how — and to what extent — might cultural forms be leveraged in LA design?** To answer this question, we examined the extent to which our tool supported educators to engage in what we call *generative uncertainty* (GU) — an interpretive stance in which educators develop productive inquiries towards data, as opposed to merely producing justifications for what is being displayed (Authors, 2021).

We make three contributions with this work. First, we build on the premise that adapting Human-Computer Interaction (HCI) approaches to HCLA can guide the design of LA artifacts and spur productive inquiry among educators (Authors, 2019). Second, we discuss how we adapt the concept of cultural forms from Interaction Design to HCLA by showing how said forms were leveraged as a design tool and taken up in practice. Third, considering that LA research does not always articulate design methods (Sarmiento & Wise, 2022), we offer a set of decisions and criteria for developing specific features of the dashboard. We then close the loop of the design-research process by comparing across design narratives that detail the adoption of our tool, and highlighting specific criteria for making decisions in HCLA design.

2. Background

2.1 Designing in Partnership

Several HCLA studies point to the centrality of designing with the participation of stakeholders (Authors, 2019; Holstein et al., 2018; Krumm et al., 2022). But how exactly should researchers allow for the "agentic positioning of teachers" (Dimitriadis et. al., 2021) to guide LA design? And how may we make design decisions based on complex, even conflicting needs expressed in the field?

HCLA researchers utilize several types of collaborative design. **One type of design that guides our work is Participatory Design (PD)**. PD emphasizes mutual learning between designers and stakeholders, and differs from other human-centered approaches, such as user-

centered design and design thinking, in the extent to which stakeholders are involved in the design and implementation processes (Bødker & Kyng, 2018; Bødker et al., 2022). The approach also differs from Codesign (CD), as the latter emphasizes collective creation that often involves multiple stakeholders (Dollinger et al., 2019). Sarmiento and Wise (2022) called for more transparent descriptions of PD and CD methods and ways in which they align with the complexity of roles, viewpoints, and routines of stakeholders. Such analyses reveal the centrality of understanding not only the user but to grasp which context they are embedded in, and their relations and organizational rites. Similarly, Dollinger and colleagues (2019) concluded that LA design studies usually describe the co-*production* of tools (ie., involving stakeholders in creating what they will use) but not necessarily in co-*creation* (i.e., the creation not only of a product but of values and relationships). Although PD has been used in the design of LA tools (Michos et al., 2020; Samuelson et al., 2019), LA still needs concrete frameworks that orient *how* such decisions can be made in complex educational settings.

A second type of collaborative design is through Research Practice Partnerships (RPPs). RPPs are initiatives that seek to address specific problems of practice within schools and communities through joint work between educators and researchers (Coburn & Peñuel, 2016). The ultimate goal of an RPP is to improve educational systems *from within* by generating knowledge — such as routines, interventions, strategies, and tools — that can reach beyond the context it was produced (Farrell et al., 2022). We understand designing in partnership as a step beyond recent moves towards human-centered design approaches, and are. We are particularly attuned to the issue of who makes which decisions when materializing needs into features, and whose agenda is being pursued throughout the PD process (Krumm et al., 2022). Prototypes and co-design sessions might serve as *boundary practices* and *boundary objects* — the routines, practices, and materials that anchor collaborative design work (Meyer, 2022). However, the "translation problem" (Penuel et al., 2015) persists: how might one reduce the gap between intentions and actual practices? To help answer this question, we turn to specific heuristics borrowed from the field of Interaction Design to guide our inquiry.

2.2 Designing from Cultural Forms

Several researchers have considered the role of culture in designing learning analytics and assessing student engagement (Cho et al., 2021; Kizilcec & Cohen, 2017; Ogan et al., 2015). In our research endeavor, we understand culture as "the acquired knowledge people use to interpret experience and generate behavior" (Spradley, 1984). Frameworks such as Value-Sensitive LA Design intentionally draw out and integrate stakeholders' values (e.g., perceptions of data ethics and representation) into LA designs (Chen & Zhu, 2019; Viberg et al., 2023). While these studies focus on individual and cross-cultural factors, our work considers schools' practices and organizational culture as guiding educators' practices. To understand the role of culture in the design of digital tools, we explored the potential contributions of Interaction Design (IxD) to HCLA. Of particular interest are the notions of *social signifiers* and *cultural forms*.

Patterns of social interaction around shared objects must be taken into consideration when designing tools and experiences. Such need for contextualization has been thoroughly discussed by IxD scholars (e.g., Hornecker, 2010), who highlight how visual aspects of objects might cue behaviors depending on the context it is employed. Norman (2008) describes human behavior as a constant search for *social signifiers* — indicators that can be interpreted by a group, and posits that systems and tools need to be deliberately designed to include these shared signifiers. In his words, "a social signifier is one that is either created or interpreted by people or society, signifying

social activity or appropriate social behavior… Designers of the world: Forget affordances. Provide signifiers" (p. 1).

Artifacts and symbolic systems are mediators of human activity (Horn, 2018; Saxe, 1999). *Cultural forms* are "historically elaborated social constructions, conventions, and systems of representations" (Horn, 2018, p. 636) that are "inherently linked to social practices and activities" (Horn et al., 2013, p. 122). Such forms are established by individuals acting together in a particular group or context, and creates an interdependence between cultural representations and routines of social practice. Once established, cultural forms may facilitate social activity and thought, and even lead to the transformation of their originating activities. One concrete example given by Horn (2013) is placing a handle on the tip of a rope. In various cultures, this seemingly simple form might evoke specific games (e.g., jumping rope) in a way a mere rope would not. A key aspect of cultural forms is that they "invite participation into patterned social activity while cueing cognitive, physical, and emotional resources" (Horn, 2018, p. 632). In practice, cultural forms are malleable, may be combined with other forms, and suggest a connection between individual and context. However, how one translates cultural forms into actual designs has not yet been explored by the HCLA field.

2.3 Generative Uncertainty

A key question when designing with cultural forms is how the design may cue social practices. A main goal of our research is to create tools that guide teacher-led inquiries into students' learning. Teacher inquiry cycle is composed of multiple actions: teachers define questions to inform teaching practices, plan for and collect data about students' learning, and analyze and reflect on the data to inform subsequent practices (Hansen & Wasson, 2016). Few LA tools to support teacher inquiry have discussed how to help teachers translate LA data into action (Sergis & Sampson, 2017). This is a complex process, as there is uncertainty associated with inferencing and making decisions with data (Alhadad, 2018).

The tool we designed throughout this work was intended to support what we termed Generative Uncertainty (GU), an analytical stance where educators work with the ambiguity of data and engage in practices that have the potential to lead to productive action from data (Authors, 2021). Considering that educators frequently experience uncertainty in their work, (Munthe, 2003), we understand productive action as transforming instances of "not knowing" into patterns where educators formulate questions, engage in improvement conversations, and devise next steps for instruction. In prior work, we find that occurrences of specific patterns — such as asking questions about the data coupled with data triangulation, information seeking, and pedagogical intentions when making sense of LA data visualizations — indicate GU (Authors, 2021). Such an interpretive stance opens avenues for productive data-based inquiry and instructional improvement. Our prior work (2021) also found that GU differs from other interpretive stances while using an LA dashboard, such as merely recalling past events with no reflection, analysis, or further instructional plans. The extent to which our designs promoted GU indicates how a feature fits and augments practices in the field.

3. Methods

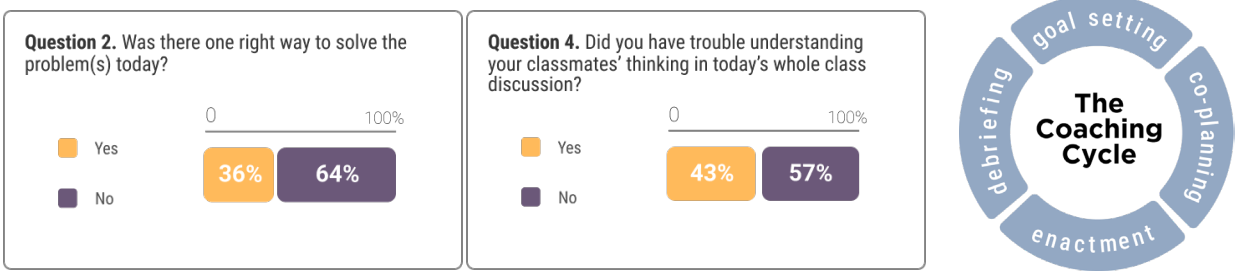
3.1. Context

This study is situated in a network of RPPs called BLINDED. Initiated in 2016, BLINDED involved three RPPs representing intensive collaborations between three school districts (Northwest, West, and South) and four universities in the United States. Members of BLINDED

shared a common goal to improve the practices of middle school math educators (grades 6 to 8) by supporting data use to facilitate student-driven learning. To ensure representation of stakeholders' perspectives, the research involved teachers and their coaches, district leaders, and researchers.

A key activity in BLINDED was the development and visualization of practical measures (PMs) focused on students' perspectives of key aspects of mathematics learning. PMs are quick formative assessments that provide actionable feedback to inform instructional action for educators (Takahashi et al., 2022). In our case, the PMs take the form of student-facing surveys that capture students' perspectives of, for example, whole-class and small-group discussions (Authors, Accepted). Teachers administer PMs as electronic surveys during class to track students' answers (Figure 1, left). The surveys are part of the work cycle between teachers and coaches (Figure 1, right): to set improvement goals that incorporate PM data (goal setting), make instructional plans (co-planning), implement the plan and collect data (enactment), and debrief to inform next steps (Kochmanski & Cobb, 2022).

Figure 1.
(left) Two sample questions from a PM survey. (right) Representation of the coaching cycle.



Upon co-developing the PMs, researchers were tasked with creating a dashboard to display PM data. We decided to develop two interfaces: one for teachers examining classroom data and one for coaches looking at their teachers' data. In this paper, we focus on the design and use of the coach-facing dashboard for two reasons. First, the coach-facing dashboard mirrors all phases (and their associated practices) of the coaching cycle, as shown on Figure 1 (right), thus creating a fertile ground for the analysis of organizational and cultural factors that influence the design and adoption of LA tools. Second, work on the coach-facing dashboard generated a 4-year long corpus of data, ranging from initial design sessions to the actual use of the tool. The dashboard was developed through a collaborative design process involving in-person design sessions with multiple stakeholders, video-call usability interviews, and site visits, among others (Table 1).

3.2. Data Collection and Participants

Situating the work in multiple RPPs allowed us to explore how the designs got taken up in different contexts. To answer the question around how cultural forms might be embedded into LA designs, we drew from several data sources to construct our *design narratives,* rich reconstructions of the evolution of a design (Hoadley, 2002) (Table 1).

First, to understand the needs and conjectures, we analyzed field notes and artifacts from annual, whole-team meetings of the RPP network, which involved BLINDED researchers, designers, and school district representatives (administrators, coaches, teachers). For four consecutive summers (2018-2021), the team came together to brainstorm design requirements and coordinate research activities. Data from these meetings involved design artifacts (e.g., pictures, notes, prototypes) and audio from presentations, group discussions and interviews. Additionally,

we included notes taken during meetings of the design team and across teams (e.g., design, PMs research, RPPs), where we collaboratively decided on the LA visuals. We also included field notes from District Northwest (2019), where we observed coaching practices and conducted focus groups with coaches and district leaders to understand their routines.

Second, we used data from pilot interviews with seven coaches, where we encouraged participants to reveal needs linked to their instructional contexts, articulate understandings of different visualizations through think-aloud protocols (Van Someren et al., 1994), and provide feedback on user experience and interface design. Interview data included researchers' memos, audio and video recordings of participants interacting with the dashboard.

Table 1.
Data Sources and Analytical Foci.

Phase	**Phase 1: Grounding** (2018-2021)	**Phase 2: In the Lab** (2019-2020)	**Phase 3: In the Wild** (2021)
Data source	Design Activities with educators during RPP gatherings.	Interviews with coaches using high-fidelity prototypes. One site visit to District West.	Coaches and teachers using the developed dashboard.
Districts	South, West, Northwest	South, West, Northwest	South, Northwest
Participants	Approximately 40 coaches, district leaders, and the RPP research team.	7 coaches.	Coach Gemma, Teacher Vera (NW); Coach Joanna, Teacher Cora (South)
Data	4 posters; 8 hours of audio and video; 4 design documents	7 interviews, (8h of audio and video).	2 cases (4h of audio and video).
Analysis	What are the needs, contextual factors, and cultural forms revealed by stakeholders and which can be leveraged?		How did the dashboard map onto existing practices? Was it able to spur GU?

Third, to understand how the dashboard was taken up in practice, we drew from two in-depth cases of educators using BLINDED between March and May 2021 (Table 2). We purposefully sampled participants who (1) attended our in-person RPP gatherings (which included design sessions) and (2) were willing to use our prototypes. Case data included audio-recorded interviews and screen recordings of educators using the dashboard in different phases of the coaching cycle, researchers' field notes of classroom implementation, and coaches' recorded notes on the dashboard as they made sense of data (i.e., making use of text fields on the tool). All sessions were recorded, transcribed, and added to our data corpus. Both cases happened during the COVID-19 pandemic, when teachers were navigating how to maintain instruction in online, face-to-face, and hybrid environments.

Table 2.
Districts and Cases, Phase 3

District / Case	Northwest (Case 1)	South (Case 2)

Coach	Gemma	Joanna
Teacher	Vera	Cora
Phases	All phases of the cycle are covered, plus a pre-debriefing between coach and researchers.	Coach's pre-debriefing with researchers; coaches and teachers co-planning and debriefing.
Summary	Vera plans instruction with Gemma, focusing on increasing students' mathematical conversations in hybrid settings during COVID. The class happens via Zoom. During the debrief, coach and teacher discuss PM data and set new goals.	Joanna assists Cora to find better task structures to support students' discussions. Students just transition back to in-person after being online due to COVID. During debrief, the coach and teacher look at PM data and revisit the goal they set at the beginning of the cycle.

3.3. Analysis

We conducted separate analysis for the three design phases, as shown in Table 1 and described below. First, a subset of our team conducted an initial, inductive coding of data from Phases 1 and 2. Our codes were informed by our theoretical framework and the RPP context of research, including codes such as "routine" (with sub-codes "debrief", and "goal-setting"), "cultural form", and "values" (associated with data-driven decision-making, pedagogy, and coaching), among others. A complete codebook can be found in Supplementary Materials A. Then, we refined the codes and created analytic memos about emergent themes. Finally, two researchers conducted the analysis with the refined codebook and reached substantial inter-rater agreement when coding 20% of the corpus (Cohen's □ range = .62-1). Any disagreements were resolved through discussion.

In phase 3, one way to examine the uptake of the dashboard was to understand if and in which part of the cycle our designed LA dashboard was leveraged, and to what extent it supported educators to reach improvement goals. To answer the second question, we looked for indicators of Generative Uncertainty among educators using the dashboard (Supplementary Materials B). For this, we coded the data for emotional, analytical, and intentional responses (Authors, 2021). Two researchers conducted the analyses and had substantial inter-rater agreement (Cohen's □ = .82).

Based on this data, and adding the use cases identified in Phase 3, we organized our findings in two design narratives to illustrate (1) how we mapped our design to cultural forms that emerged through PD, (2) how the dashboard was used by educators, and (3) whether the designs promoted generative forms of inquiry.

4. Findings

During design phases 1 and 2, cultural forms such as binders, notebooks, calendars, and celebration cards often emerged during site visits, interviews, and design sessions. Some of these forms were directly manifested by participants and observed in use (e.g., notebooks), while others were interpreted by our team based on our observations (e.g., representing recurrent cycles into timelines). Across interviews, participants also voiced how establishing *interpersonal relations* should precede the use of any digital tool such as the one we were about to design with them, and that *dialogue* was central for establishing a joint direction to pursue. In this section, we present two design narratives based on data from all three phases of the project. Both narratives are centered on a full design cycle of a particular dashboard feature, each aimed at matching and augmenting a key coaching practice observed in the field.

4.1. Narrative 1 — Goals: Aligning Dashboards with Routines and Practices

How might a teacher visualize which data point contributes to a specific instructional goal and what data to collect next? Narrative 1 is centered around *goal negotiation*, a key practice observed in coaching in all participating districts. Data from Phases 1 and 2 revealed that setting an instructional goal takes careful negotiation between coaches and teachers, and should not be imposed by coaches over teachers. Consider, for example, coach Laura's words (West, Phase 2):

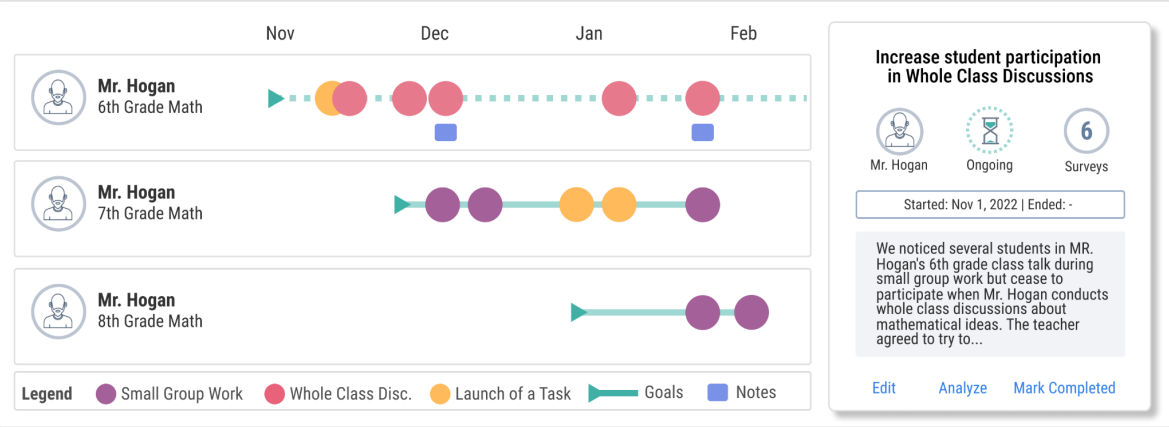
> I think it got to be a conversation. It's going to be something where the teacher is able to have some kind of control or choice. There has to be teacher interaction in order for teachers to feel like the system [is] not being placed upon them, because that will kill a coaching relationship.

Similarly, in Coach Norma's (South, Phase 2) words, "We always try to negotiate [the goal]. I don't ever want to push it because it's the teacher's classroom and the teacher is growing". Based on the centrality of this practice, we sought to translate goal-setting into a prominent feature of our dashboard. Drawing from Phases 1 and 2, this feature was designed to match both synchronous negotiation of goals (i.e., educators using the platform together to jointly establish new goals) and asynchronous goal-setting (i.e., coaches add negotiated goals, while teachers add the corresponding classroom data; see Figure 2). For this task, we drew on two cultural forms that our design partners brought up frequently: *calendars* and *celebration cards* (i.e., to signal progress towards a goal). After collecting these cultural forms from the field, two central questions remained. First, what exactly do these forms tell us about the experiences, practices, and routines of our partners? Second, how should we leverage such forms while designing our LA dashboard?

To answer this question, we investigated what shared meanings and practices — or social signifiers — were hidden behind these cultural forms. We engaged in check-ins with various RPP members whose work was closer to school-based educators (e.g., researchers and district leaders). The cultural form of a Calendar, for example, revealed how coaches and teachers conceptualize instructional improvement as a sequence of interdependent events that feed into previously negotiated goals (*timelining)*. Coach Janet's words (South, Phase 2) are an example of timelining: "We started setting goals, and then negotiating them. I would go and observe and then debrief and give feedback. And we started all over again". Delving into educators' calendars also highlighted how they performed longitudinal data analysis to triangulate instructional data events (*time triangulation*). Similarly, celebration cards revealed how educators signal progress acknowledgement to each other (*signaling*). Cards also pointed to how interpersonal relations were carefully crafted between coaches and teachers, and deeply anchored on previously negotiated goals (*relationship building*). We then set out to design elements that would facilitate and augment these practices (Table 3).

After successive sessions, we designed the feature displayed in Figure 2. Our main conjecture was that mirroring forms and practices observed in the field would lead users to make sense of data based on established goals, therefore creating an opportunity for generative uncertainty (i.e., as opposed to examining data without the context of a goal). (Supplementary Materials B) We also conjectured that linking instructional events, goals, and celebrations in a timeline would encourage transparent dialogue and trust between teachers and coaches. Thus, coaches could add goals (green triangles with dotted lines), add comments, perform longitudinal analysis of all surveys pertaining to a goal, and mark goals as completed (represented as full lines). Colored circles crossing green lines represent different PM surveys administered by teachers to students in pursuit of a goal.

Figure 2.
(left) Teacher's goals on a timeline, as seen by a coach. (right) Goal description and details.



But how was this feature used in practice? Phase 3 revealed that this design decision mapped onto planning and debriefing routines. To illustrate these uses, we focused on Coach Gemma and Teacher Vera (Northwest, Case 1), and Coach Joanna and Teacher Cora (South, Case 2). Case 1 represents a coaching cycle focused on increasing students' mathematical conversations in hybrid settings during the COVID outbreak, where half of the students were taking the class online and half were in face-to-face instruction. Case 2 focuses on providing additional opportunities for students to interact with each other's thinking.

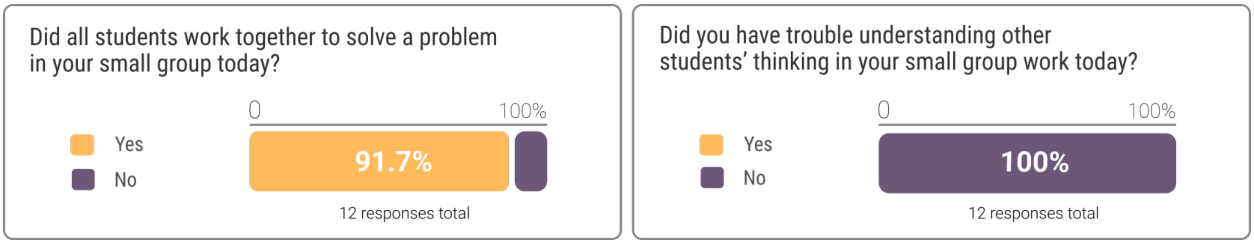
We found three instances of GU when coaches set new goals. For example, Coach Gemma discussed with Teacher Vera that, in a particular survey, almost all students in a class stated they worked collaboratively to solve a math problem and had no trouble understanding each other's ideas during small group work (Figure 3). Given the hybrid context of COVID, where part of the students was at home with no direct adult supervision, coach and teacher discussed if the same positive results would remain with reduced guidance from teachers. Gemma recalled her conversation with Vera:

> One of the things that we talked about in the debrief was if the goal is still that students have productive Math conversations, regardless of whether there's an adult in the room. We were just continuing to think about what structures have supported that in the past or new things to try.

The quote above illustrates a case of GU, with educators seeking further information about actions that could increase student participation. When prompted to select specific PMs to attach to a goal, Gemma considered which measure would be the most appropriate to support students to have productive conversations, showing how a feature (i.e., linking PMs to goals) mapped onto educators' routines and cultural practices (goal negotiation):

> I'm thinking about productive group discussion… I'm struck by the different measures. If our [professional development] group is around small group work, being able to look at multiple [surveys] over time is useful. I'm thinking about capturing things that are unique about that day when comparing across time, because we know there are such unique things about every lesson.

Figure 3:
Small group work data.



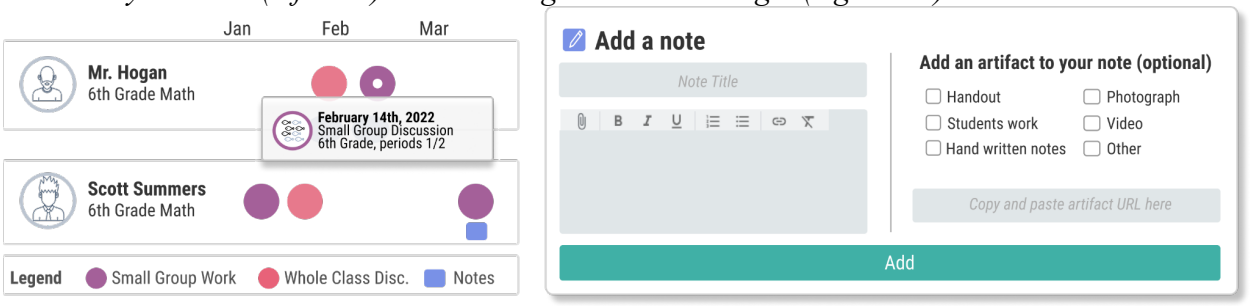
4.2. Narrative 2 — Notes and Collages: Oversold and Underused

During Phases 1 and 2, when asked about future affordances of the dashboard, educators pointed to two cultural forms: *notebooks* and *binders*. This request was confirmed in our visit to District Northwest, where we observed how coaches walked with thick notebooks, where they kept notes of classroom observations and debriefs and attached various forms of data such as planning sheets. Some coaches used large binders in addition to notebooks, to gather materials connected to the teachers they were supporting at the moment. But what shared practices existed behind notebooks and binders, and what should be represented by our designs?

To answer these questions, we conducted check-ins with RPP members and reviewed data from Phases 1 and 2. In District South, Coach Adelia (Phase 2) described how her current practices should be reflected by a future dashboard: "I sent a summary of the debrief conversation [to teachers] and kept a physical copy with me. What I want [from a dashboard] is a binder that has everybody in it". We termed this need for "having everybody in it" as *rostering*, a practice in which coaches seek a general view of their mentees, all in one place. We also learned how coaches would attach ancillary data, such as lesson plans, handouts, and photographs, to quantitative data (Wardrip & Herman, 2018). We termed this practice *data collaging*, and saw a great potential for further data triangulation. Coaches often associated notebooks with *synchronous note taking* (i.e., in-situ and while a particular event such as class or debrief was happening) and *asynchronous note taking* (i.e., as a reflective practice, in preparation for a goal negotiation or a meeting with a teacher) (Table 3).

The next step was leveraging notebooks and binders into our design process. First, we embedded multiple ways for note-taking: we added open-ended text boxes whenever teachers examined the data, and as prominent visual markers on the coach-facing dashboard, where such educators would not just write notes but add other forms of additional data (Figure 4). The dashboard also kept a running log of the notes and displayed them side-by-side with the data collection events (blue squares, Figure 4). We allowed teachers and coaches to add different forms of ancillary data to notes (thus reflecting the binder), all visible in the timeline, and referring to different stages of a coaching cycle.

Figure 4.
The survey timeline (left side) with an integrated notes widget (right side).



While the design for note-taking features appeared to align with what educators voiced as needs and their observed practices, analyses of the adoption of the dashboard showed limited to very little use of this feature. For example, Coach Joanna (South) initially reacted very positively to the possibility of keeping a log of notes on the dashboard: “Every action I take is always going to be right here”. Joanna even reminds teacher Cora to take notes during their co-planning: “If you want, go back [and] remember [...] any notes you want to take [...] to keep it fresh”. Despite such initial, positive reactions, educators in both districts did not frequently take notes on the dashboard when using it in the field (except when directly prompted by researchers). Instead, coaches continued using pen and paper. Consequently, no ancillary data was attached to the dashboards to anchor conversation during coaching practices, and no forms of productive inquiry were noticed in association with such features.

To reflect on how such limited use of artifacts and note taking features contrasts with the positive uptake of goals on the dashboard, we turn to a comparison of both narratives.

4.3 Cross-case Comparison

An emergent goal within all three RPPs was to use the dashboard in ways that did not just fit institutionalized practices, but challenged instrumental uses (i.e., creating confirmatory narratives based on data), and promoted generative forms of inquiry. We approached this design challenge by identifying cultural forms present in schools and examining which practices, behaviors, values, and structures they were associated with (Table 3). In both Goals and Notes narratives, the social signifiers embedded in our designs were promptly identified by educators. For example, educators recognized that goals functioned as anchors for data events that got represented in a timeline. Likewise, a digital notebook and its associated binder (i.e., the "add artifacts" feature) were recognized as signifiers of an activity habitually performed by coaches.

The main dissonances were revealed when we examined to what extent social signifiers mapped onto underlying practices of our population. Table 3 summarizes the cultural forms collected in the field; the practices, behaviors, values, and structures they represent; and our final designs. For example, the set of designs associated with signifiers for Goals cued the desired social activities: coaches and teachers were able to perform timelining, triangulating data points, and signaling progress. Conversely, the designs associated with signifiers for Notes only gave partial access to key social activities performed by users. For example, while our features did allow rostering (i.e., displaying all mentees at once, filtering people, etc.), data collages did not allow coaches to see more than one form of data at once as a physical binder does, thus not affording visual triangulation of data. Additionally, the current designs of the Notebook cued coaches to take notes when facing data (such as in debriefs with teachers), but missed out on key synchronous moments such as class observations.

Comparing across narratives revealed where leveraging cultural forms was not enough to cue the desired action and promote GU among stakeholders. In the next section, we discuss the main implications of such findings by proposing additional criteria for making design decisions.

Table 3.

Understanding Cultural Forms and their Underlying Practices.

Cultural Form	Underlying practices, behaviors, values, and structures.		Designed Feature
Calendar	Timelining	Instructional events are sequential and interdependent.	**Goals:** adding goals, linking goals to PM

	Time Triangulation	Going back and forth in time to make sense of data.	data, marking goals as completed, celebrating progress towards goals.
Celebration Cards	Signaling	Showing appreciation or acknowledgement of progress towards a goal.	
	Relationship building	Building interpersonal relationships based on meetings or improving goals.	
Binder	Rostering	Building a general view of all teacher mentees.	**Notes:** adding notes to a data point; adding various types of artifacts to a note.
	Data Collaging	Collating ancillary data relating to an improvement goal or instructional event.	
Notebook	Synchronous note-taking	Taking notes in-situ, while observing a class, negotiating a goal, etc.	
	Asynchronous note-taking	Taking notes after instructional events (e.g., in preparation for a meeting)	

5. Discussion

The dissonance between designs and stakeholders' practices poses a crucial challenge to the adoption and use of LA tools. Although the field has turned its attention to approaches that include stakeholders in the design of their own tools (Holstein et al., 2018; Krumm et al., 2022), design plans and uptake of LA tools may still present several misalignments. In this section, we present three contributions for reducing the design-to-adoption gap and creating a necessary HCLA design grammar.

First, intentionally identifying and leveraging cultural forms is a step towards designing and deploying LA tools that match and augment users' practices. Grounding LA research and design work in meaningful educational contexts is key for the uptake and sustained use of tools (Michos et al., 2020). For that reason, LA designers need to actively look for cultural forms and social signifiers specific to each community or sub-group of end users. By cultural forms we do not mean the practices that are widely shared and known by a large group of users (e.g., idiomatic expressions, national symbols, etc.) but the micro practices that pertain to specific groups of stakeholders — in our case, K-12 instructional coaches. Moreover, by linking designs that are based on specific cultural forms observed in the field to their use and the extent to which they promote inquiry, researchers can discern to what extent designs worked well, and where missteps may have occurred. Beyond measuring *how much* a tool is used (e.g., by counting accesses or clicks), assessing GU provides a tangible framework to understand *how* and *to what extent* the tool might facilitate data sensemaking.

Second, prototypes and PD sessions play a crucial role within RPPs. Although such boundary practices and boundary objects — or the routines, practices, and materials that anchor collaborative design (Meyer, 2022) — were utilized, this study still faced significant design challenges. Besides practices and objects to facilitate our work, we only partially engaged in *boundary crossings*, when researchers and practitioners navigate and cross the intersections of their domains (Akkerman & Bakker, 2011). Although designing with cultural forms provides a starting point for boundary crossings, we learned that it is insufficient if we do not investigate the social practices that the forms signify. Narrative 2 illustrates this finding: despite having captured

the forms of notes and binders, our designs did not adequately cue additional, key practices associated with the forms such as data triangulation and synchronous note-taking. A key lesson learned in this case is that boundary crossings call for more holistic and comprehensive representations of multiple vantage points and practices across RPP stakeholders.

Finally, two additional design criteria might have mitigated the design-to-adoption gap. First, signifiers need to provide *task concreteness* about what the intended and alternative social activities are. For Goals (Narrative 1), the calendars and celebration cards signal recognizable actions and concrete tasks associated with the coaching cycles to set and negotiate goals and celebrate their completion. Meanwhile, note-taking (Narrative 2) can take different forms depending on individuals' uses, and our current design (Figure 4) might provide little structure and expectations around how to use this feature (leading to confusion, large variability, or little use of the feature). Second, social signifiers and cultural forms should enable *ease of use* if they are to cue intended behaviors. A consideration that emerges is whether our design introduces or alleviates frictions for users, despite being aligned with signifiers. For example, the typing of notes into a digital platform might introduce friction, compared to current writing practices with pen and paper that are more accessible.

Together, these findings may help designers trace usage back to intentions, and reflect upon decisions, alternatives, and potential pitfalls. From considerations of alignment with cultural forms, concreteness of task, and ease of use, designers may consider scenarios that articulate how tools might contribute to user's action and experience, and how such interactions might be factored in to align designs and uses.

6. Limitations

This work has two limitations. First, the study was conducted with a small sample of educators, who worked closely with researchers within long-term RPPs. Second, although our investigation happened in naturalistic settings (i.e., real classrooms), the study participants were all educators who wanted to contribute to the co-design and testing of a LA tool. Future research that involves a broader range of stakeholders and learning settings can further illuminate the many opportunities and challenges to the design and adoption of LA tools.

7. Conclusion

Our work contributes to a deepened understanding of how to translate traces of human activity into the design of LA tools. Intentionally integrating cultural forms into the design of Learning Analytics can encourage uptake and invite generative inquiries among educators. Culture-to-design translations, however, rest upon a systemic understanding of the social practices behind forms and signifiers. Additional design criteria, such as task concreteness and ease of use, are needed throughout the development process. We encourage future design-research studies to engage in thick, systemic inquiries into real-world educational settings to reveal why and under what circumstances LA tools might work.

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