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**Audra Skukauskaitė (College of Community Innovation and Education, University of Central Florida)**
**Susan Bridges (Faculty of Education, University of Hong Kong)**
**Michelle Sullivan (School of Engineering, Massachusetts Institute of Technology)**

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# An Interactional Ethnographic Exploration of In-Time and Over Time Mentor-Student Interactions in Invention Education

Audra Skukauskaitė[1], Susan Bridges[2], and Michelle Sullivan[3]

[1]College of Community Innovation and Education, University of Central Florida
[2]Faculty of Education, University of Hong Kong

[3]School of Engineering, Massachusetts Institute of Technology

## ABSTRACT

Dialogue is central to the collaborative processes of inquiry-based approaches. In this methodological article on Interactional Ethnography (IE), we outline the guiding principles of IE as a logic of inquiry for studying the talk and actions of learners and their mentors in inquiry-based learning. Through a telling case of facilitation processes in high school invention education (IvE), we illustrate the major steps and analytic processes that an IE research team undertakes to collect, archive, and analyze records of classroom learning. We share how the IE team enters this ethnographic space and undertakes video-enabled microethnographic discourse analyses of in-time and over time events to identify key learning processes and develop warranted interpretations. Specifically, we exemplify how the ethnographers conduct nuanced analyses of learning discourse in-the-moment and over time. In the context of invention education, we share how an IE study enables the researchers to trace the developing cycle of inquiry and make visible the processes that support design thinking in invention education.

*Facilitation is one of the central and complex aspects of PBL. Although it may often mistakenly be perceived as passive…. effective facilitation is central to the success of a PBL group's social processes and learning. (Hmelo-Silver et al., 2019, p. 297).*

Given this Special Issue's interest in methodologies, in this paper we introduce Interactional Ethnography (IE) and demonstrate IE's methodological potentials in uncovering in-time and over time complex processes and practices of inquiry-based learning. In problem-based (PBL), project-based (PjBL), and other inquiry-oriented educational approaches such as invention education (IvE), facilitators are instrumental in modeling reasoning processes through which students explore ideas, make connections between claims and evidence, become more reflective, and develop metacognitive skills (Ertmer & Glazewski, 2019). Together with the students, facilitators such as teachers and adult mentors coconstruct cultures of a classroom or after-school group in which learning is problem driven, iterative, and responsive to real-world needs of the immediate and larger communities.

To demonstrate the methodological potentials of Interactional Ethnography, we drew on a telling case in IvE and examined adult expert mentors' facilitation of the work of high school students engaged in inventing a prototype solution for a real-world problem. In this telling case we illustrate how in-depth, ethnographic over time, and

microethnographic moment by moment in-time discourse analyses of interactions can make visible the complexities of facilitation processes to address the often-mistaken perception of passivity noted in the quotation above.

**Invention Education and Inquiry Designs**

We are approaching two decades since Savery's (2006) exposition on varied inquiry-based approaches outlining the collective goal as engaging and stimulating student-led and teacher/mentor facilitated tasks. Although a relatively younger member of the inquiry-based learning family in school settings, the underlying epistemology, goals, and strategies of facilitation of IvE are closely aligned with those established in the PBL literature (Skukauskaitė et al., in press). Like PBL and PjBL, IvE focuses on learners actively engaged in solving ill-defined and complex "wicked" problems, usually with the facilitation and guidance of more experienced others, such as teachers, tutors, and varied mentors. Since Rittel and Webber (1973) first introduced the notion of "wicked problems" in architecture, much has been written on the role of the problem (and case) design as a stimulus for inquiry; nevertheless, there is agreement that the "ill-defined" problem is the driver of the inquiry process (Savery, 2006).

Whether logical problems, dilemmas, medical cases, or engineering design problems, each problem leads to planning decisions about learning activities, inputs, success criteria, context, structuredness, and abstractness (Jonassen, 2000; Kolodner et al., 2003). More open and ill-defined problem stimuli can take a broad focus on "problem understanding" to capture the complexities of the dimension of the problem. Jonassen and Hung (2008) found that design problems and strategic-performance problems may lean towards applied "problem solving". Across these approaches, the problem comes first, setting the group on a path of exploration and ideation. In IvE, the problem is usually student generated and based on interactions with the community rather than planned and delivered by the instructor (Invention Education Research Community, 2019; Skukauskaitė et al., in press).

A brief examination of the philosophy, curriculum design, and approach to classroom pedagogy in the range of inquiry-based approaches assists in framing the study below and our interest in facilitation strategies in IvE (Lu et al., 2014). As a philosophy, inquiry-based approaches share a common grounding built on Dewey's initial focus on learner curiosity as well as on socio-cognitive and sociocultural understandings of learning as a coconstructed process that supports students in developing flexible knowledge, problem-solving, and self-directed learning (Hmelo-Silver, 2004). Inquiry-based educational approaches draw on Vygotskian sociocultural theories as well as varied conceptualizations of constructivism and constructionism (Edelen & Skukauskaitė, 2022; Gubrium & Holstein, 2008; Vygotsky 1978), ranging from cognitive models of constructivism to Piaget's (1977) social constructivism to varied versions of constructionism (Phillips, 1995; Von Glasersfeld, 2000), including Papert's (1993) applied focus on learning by doing and the cocreation of artifacts.

As we argue elsewhere in work on PBL, cognitive and social principles support a situated approach to learning, driven by both the contextual authenticity of the problems and issues at hand and the social dimension of mentored learning with peers in groups (Bridges et al., 2020; Hmelo-Silver & Barrows, 2015; Lave & Wenger, 1991; Walker & Leary, 2009). This applies also to invention education where learners in groups design solutions to real-world problems anchored in their communities. From a curriculum design perspective, a cycle of inquiry provides a useful nonlinear heuristic which recognizes the sequencing of learning processes. Pedaste et al.'s (2015) synthesis of the range of inquiry models mapped the basic structure of inquiry cycles to the following general phases which may follow various pathways and iterations:

- orientation or problem statement
- conceptualization
- investigation
- conclusion
- discussion

As the purpose of this article is to introduce IE as one approach to studying inquiry-based approaches, it is important to note that a core IE principle of nonlinearity introduced below closely aligns with PBL, PjBL, IvE, and other inquiry-based pedagogical approaches which presume learning as nonlinear, iterative, and over time processes. The nonlinearity principle enables interactional ethnographers to trace and explore roots and routes taken in the complex and often iterative learning processes and to uncover cultural practices as coconstructed through language and actions of the insiders (i.e., members of the group studied). [1]

1 A note on terminology

Much like all areas of research, IE contains language that may be unfamiliar or used differently than other areas of ethnographic or broadly qualitative inquiry. As such, we include the following definitions: An insider is a researcher, participant, or other member of a culture who is familiar with cultural norms, practices, and contexts (Hammersley & Atkinson, 2007). Conversely, an outsider is a researcher or participant who is not a member of the culture being studied, thereby lacking familiarity with the culture's norms, practices, and contexts (Hammersley & Atkinson, 2007). Insiders and outsiders exist

Another key aspect in the suitability of IE for studying inquiry-based learning is how the cycle of inquiry provides a clear overall boundary for establishing telling cases and examining smaller event boundaries constituting the inquiry cycle (see Table 1). As in prior work in dental, medical, and speech language therapy education, tracing within and across the events of a cycle of inquiry can make visible multiple facets of the collaborative and iterative inquiry-based learning processes (Bridges et al., 2012, 2016, 2020).

In addition to philosophical and curriculum design perspectives, inquiry-based approaches share a classroom pedagogy focused on collaboration on real-word tasks, with clear scaffolds and support for student self-directed learning in groups and individually (Collins & Kapur, 2014). Across all variations on the inquiry continuum, a central scaffold in the learning process is that of the instructor as facilitator. Whether the role is framed as a teacher, mentor, or tutor, the role of facilitators is to support the group process of "nailing down" ideas within the larger context of the inquiry cycle. Facilitation processes support "apprenticeship in thinking," monitoring and providing a range of prompts to guide students as they reason through, in the case of IvE, the design challenges (Couch et al., 2020; Hmelo-Silver, et al., 2019, p. 299). Savery (2006) argued that the primary difference between facilitator roles in PBL and other forms of inquiry learning rests in "information giving," with PBL discouraging direct instruction by expert tutors while in other inquiry approaches, such an IvE, the facilitator not only supports learning processes but also provides information when needed and requested by the students. As we will illustrate below, the balance between assisting learners to articulate their thinking and direct instruction is important to IvE, in which students work on developing prototypes to solve a real-world problem (Couch et al., 2019). The instructor-as-mentor seeks to facilitate student-driven design processes through a variety of interactions, including listening and dialogue, modeling of reasoning processes, use of physical scaffolds (drawing, etc.), and sharing of information students have not yet learned in school.

An interactional ethnographic focus on the talk and actions of learners in situated contexts provides a systematic approach to tracing the facilitation process through microethnographic discourse analyses (ME/DA) (Green et al., 2020). As we illustrate below in the application of the interactional ethnographic epistemology to studying mentor-student interactions in an IvE setting, ME/DA analysis supports nuanced understandings of facilitation as pedagogy in inquiry-based learning.

on a continuum and may move closer to insider or outsider status throughout the course of a program or research study (Skukauskaitė & Girdzijauskienė, 2021). This continuum acknowledges the multiple, shifting positionalities individuals occupy over time.

## Research Design

### Overview of Interactional Ethnography

Interactional Ethnography is a transdisciplinary logic of inquiry through which researchers and practitioners explore how members of particular groups coconstruct their ways of being, knowing, and acting in the group (Skukauskaitė & Green, 2023b). IE was created by a group of education researchers with backgrounds and interests in literacy studies, anthropology, sociolinguistics, sociology, policy studies, leadership, and related fields. Drawing on sociolinguistics and ethnography of communication (Gumperz & Hymes, 1972), language studies in classrooms (Cazden et al., 1972), anthropology (Heath, 1982), sociology and applied ethnomethodology (Heap, 1990), and education research (Green, 1983; Smith & Ennis, 1961), the early interactional ethnographers sought to develop systematic ways of studying and talking about learning in context.

In analyzing classrooms as cultures in the making, IE researchers examine learning as a longitudinal, active process enacted by teachers and students through their situated interactions and activities (Rex, 2006; Skukauskaitė & Green, 2023a). In this reenvisioning of education as an active, longitudinal, languacultural process, the early IE scholars drew on sociocultural and sociolinguistic theories and social justice movements in the U.S. since the 1960s. They also built on and contributed to the expanding research approaches which valued other ways of knowing, including women and minority perspectives and teacher knowledge (Erickson, 2018; Green & Stewart, 2012; Skukauskaitė et al., 2015). Responding to the previously dominant measure-driven post-positivist views of learning and process-product interventionist models of education (Rex et al., 2006), IE grew as a more inclusive, socially responsive, and complex epistemology to conceptualizing and studying education, learning, and social life with, not merely about or on, people whose lives and learning researchers sought to study and understand (Green et al., 2003; Skukauskaitė & Green, 2023a). Interactional ethnography foregrounds the actions and perspectives of insiders who, as members of their developing groups, collectively coconstruct their social lives and grant researchers the privilege of access to observe, interact, and learn with and alongside the group members.

**IE as Epistemology: Guiding Principles and Analytic Processes**

IE is sometimes referred to as a methodology for research; however, because it is not a set of prescribed interconnected procedures but a way of knowing, thinking, and viewing the social world and the phenomena of interest, IE is more accurately described as epistemology (Skukauskaitė, 2023). As an epistemology, IE shapes what phenomena researchers select to study and how they come to know and understand these phenomena (Green et al., 2015). As an epistemology that developed through the intersections of education, anthropology, sociolinguistics, and sociology (Skukauskaitė & Green, 2023a), IE conceptualizes learning and everyday life as longitudinal, consequential, and coconstructed in and through in-time and over time actions and interactions in particular groups (Green & Bridges, 2018; Putney et al., 1999), situated in layered local and global contexts (Green & Heras, 2011; Skukauskaitė & Girdzijauskienė, 2021). To understand how learning takes place over time as enacted by members in cumulatively consequential moment by moment actions and interactions, interactional ethnographers study the ways people talk meanings into being (Green & Dixon, 1993) within particular groups or communities such as classrooms or networks. To understand the consequential processes of learning, IE researchers pay particular attention to discourse and explore languaging[2] processes (Bloome et al., 2022; Hong & Bloome, 2023), multimodal materials and their use (Bridges et al., 2020), and interconnected events, people, spaces, and activities (Bloome et al., 2009; Bridges et al., 2020) through which members of a group coconstruct languacultures (Agar, 2006) specific to their group. Interactional ethnographers draw on Agar's notion of languaculture to mark the inseparability of language and culture and thus foreground the active processes through which any social group, such as a class or a team, actively cocreate ways of speaking, being, acting, and meaning-making particular to the group.

Interactional ethnographers draw on four guiding principles which not only inform how researchers conceptualize the problems and phenomena they study, but also guide ethnographer actions throughout the research process. Table 1 below provides the principles, some of the ways the principles inform the conceptualizations of what is studied, and the key actions ethnographers need to take in their research.

In constructing this table, we drew on the principles proposed by Green et al. (2012), who built on the earlier IE work (Green et al., 2003; Santa Barbara Classroom Discourse Group, 1992) to demonstrate the principles and implicated actions. In explaining the principles and the way they guide research conceptualization and actions, we also drew on related work in IE, including Green and Bridge's (2018) principles of conduct and the recent edited volume on interactional ethnography (Skukauskaitė & Green, 2023b). Together, the principles and the way they guide conceptualizations of phenomena and research practices, demonstrate how IE (like most ethnographies) (Skukauskaitė, 2023) is an epistemology—a way of thinking, seeing, and acting. In summary, IE practices include:

- understanding groups as languacultures in which people are constantly engaged in cocreating their culture-in-the-making through their discursive choices, languaging, and over time activity.
- taking a learner stance and engaging in reflexivity. Learning, like culture-cocreating, is iterative, recursive, and never ending, and involves the researcher taking a learner stance and setting aside their own knowledge.
- engaging in research over time through at least one natural cycle of activity. In the nonlinear practices of life there are natural cycles of activity which can become visible retrospectively or as signaled in the insider-created plans and actions.
- following insider perspectives. Insider actions, language, and perspectives signal what is important to be studied and how it can be/needs to be understood.
- analyzing the coconstructed meanings and actions both in the moment and over time in nonlinear ways to make connections and develop contextual understandings of languacultural processes and practices.
- drawing on multiple sources of data and analytic methods to construct a culturally responsive (re)presentation of the group and its activities. Ethnography is not just a qualitative approach (Skukauskaitė, 2023; Walford, 2020); in addition to primary methods of participant observation, video analysis, and varied forms of interviewing, ethnographers may utilize other data collection and analysis methods, such as photo elicitation, stimulated recall, artifact, and document analyses, as well as statistical instruments, such as surveys or pre-post tests.

Underlying these IE practices is the IE goal to understand the group, its languaging, its activities, and its languacultural meaning-making in multifaceted, complex, culturally

2. Languaculture describes the interdependent relationship between language and culture, emphasizing the way the two interact (Agar, 2006; Hymes, 1974). Languaging refers to the process of using language to create meanings, construct social identities, and negotiate social interactions within specific languacultural contexts (Hong & Bloome, 2023).

| Principle | Conceptualizing phenomena | Enacting research in practice |
|---|---|---|
| Ethnography is nonlinear | • Life is nonlinear.<br>• Language and culture are inseparable.<br>• Encountering new languacultures creates frame clashes which can lead to rich points.<br>• People (re)construct meanings for their lives in the tellings and interactions with others, including the researcher | • Follow natural cycles of activity of the languaculture studied<br>• Expect the unexpected<br>• Rich points are opportunities for learning<br>• Analysis and focusing in can start from any moment in time, or any rich point<br>• Backward and forward mapping to and from the rich point can reveal languacultural meanings and patterns |
| Stepping away from ethnocentrism | • The groups and languacultures we study are unique and should not be judged or compared with others without first understanding the group as its own languaculture<br>• People signal what is important to them and how they conceptualize the phenomena of relevance. | • Cultural relevance<br>• Creating mutually responsive relationships<br>• Researcher reflexivity<br>• Researcher as learner<br>• Longitudinal engagement<br>• Listening, observing, and collecting a variety of artifacts<br>• Focusing on insider points of view<br>• Exploring a variety of perspectives<br>• "Translating" with and for varied audiences. |
| | • The goal is to understand the languaculture of the group from their insider points of view | • Engaging with languacultural guides |
| Identifying boundaries | • Insiders signal boundaries and significance through their language and actions<br>• Languacultural activity is longitudinal and consequential, often intended for delayed response<br>• Boundaries become visible post hoc | • Generating and collecting multiple records and sources of data<br>• Video and audio recording everyday interactions<br>• Analysis of in-time construction of meaning<br>• Analysis of over time patterns |
| Making connections | • Each languaculture is situated in layers of contexts<br>• Words and actions have histories<br>• The "general is in the specifics"<br>• Each ethnography is *a* (re)presentation (not *the* representation) situated in time, space, sociohistorical contexts, and shaped through the personhood of the researcher and their relationships with the participants | • Doing homework before going into the site—studying the literature and any potential information about the group, then bracketing it upon entry<br>• Creating relationships with key languacultural guides<br>• Examining actions over time<br>• Triangulating varied sources of data, multiple perspectives, and theoretical constructs<br>• Acknowledging limits to certainty<br>• Inviting readers into dialogue and learning |

Table 1. Interactional Ethnographic Principles as Guides

responsive and insider-accountable ways. IE is good for studying any group and setting in which members interact over time to accomplish particular goals, such as learning and interaction in educational settings. Because IE focuses on discourse and how people create their languacultures and meanings through languaging, IE is useful to study phenomena which require in-depth analyses of moment by moment interactions and how those interactions become consequential over time. IE supports microanalyses of everyday interactions and events (e.g., one activity or one moment in the interaction) and connects such interactions to meso-level contexts and norms (e.g., classroom or school) as well as to the macrolevel policy, sociohistorical, and socioeconomic influences. IE often starts with rich point analyses and uncovers how and why members of languacultures act, interact, and create meanings in particular ways and with particular collective and individual outcomes and consequences.

In the next section we provide an example from a study in invention education (IvE) and demonstrate how the IE principles enabled us to uncover the way a teacher, adult mentors, and a group of high school students purposefully and systematically engaged in the ill-defined problem-based IvE processes. The phenomenon of interest for this study is the way adult mentors facilitate student learning in IvE, which, in a previous article in IJPBL, we have conceptualized as one of the educational approaches aligned with the overall PBL/PjBL goals (Skukauskaitė et al., in press). To understand the practices and processes of adult mentors facilitating student learning, we drew on the principles and practices interactional ethnographers utilize for their studies.

## A Study Example

### Data Sources

In this methodological article we drew on two sets of ethnographic records constructed over two years. The first set of records was constructed by a team of high school students and their teacher in Oregon working on inventing a prototype of an adaptable cup for people with dysphagia (difficulty swallowing). The records consisted of the team ethnographer's (student historian) notebook with links to the video records of the team's activities for each day of an 8-month project, photographs the teacher and students took during the year, and publicly available records of the team's activities (including media articles about the team and the team's GoFundMe campaign page). The second set of records includes six months of video recordings of weekly interview conversations (Skukauskaitė & Sullivan, 2023) with the teacher and the team's student historian. In these weekly Zoom-enabled conversational interviews with a research team from a university in Florida, the teacher and the student historian explained events captured on video, provided background explanations about the processes, practices, and networks of support, and reflected on their life and learning the previous year.

In this study we utilized primarily the first set of records from the high school team, but we drew on the conversations recorded in the second set of records to add explanations of what meanings the insiders constructed for the activities recorded in the first set of videos. Using two sets of archived records enabled us to explore interconnected events, how the events were constructed moment by moment in situ, and how they developed and were consequential (or not) over time.

### Research Site and Participants: InvenTeam Program

The first set of records came from the InvenTeam program, sponsored by the Lemelson-MIT Program (LMIT) at the Massachusetts Institute of Technology (MIT). Over the past two decades, LMIT has promoted IvE and has been administering grants for high school teams who apply with an idea to develop a unique and novel solution to a real-world problem in the students' community. In 2018, a high school team from a small, primarily low-income town in the Pacific Northwest of the United States, received a $10,000 grant to develop a working prototype to address the problem people with a medical condition of dysphagia face. Dysphagia causes difficulty swallowing, so the team proposed to design a cup with adjustable flow of liquid. Upon receipt of the grant in November 2018, the team worked over the academic year to design and develop the cup, engage community in the feedback, and present their design locally and at a final celebration at MIT. The team consisted of 11 students, 73% of whom were female. Eight students identified as Latinx, one as Asian American, and two as White. Before and during the InvenTeam year, the facilitating teacher taught mathematics and, later, engineering and career and technical education (CTE) courses.

The InvenTeam program took place after school and on the weekends, and the team put in more than 250 hours in developing their working prototype presented at MIT. In addition to common InvenTeam student roles such as Communications, Finance, and Technical leads, this team piloted a new role of a Student Historian. The student historian collected video/audio records and kept a historian notebook throughout the year as records to be shared with the LMIT research teams.

Two adult technical mentors not affiliated with the school supported the InvenTeam throughout the year. The first was T, the teacher's husband, who at the time was enrolled in a graduate engineering program. The second technical mentor was CG, an independent engineer whom the teacher and

her husband had met at one of the state engineering design competitions and who had become a family friend. CG lived about 50 miles from the school but was a frequent visitor at the InvenTeam's meetings after his first visit on February 23rd, 2019. The "technical mentors", as the program called their roles, T and CG were instrumental in helping students learn coding, computer assisted design (CAD), 3D printing, and other engineering and technical content knowledge the majority of students did not have prior to the InvenTeam year.

All students had signed assent forms, while the teacher and technical mentors had signed consent forms to participate in the research. The first author of this paper was affiliated with LMIT as an independent researcher at the time of study design and data collection and had access to the InvenTeam records. The following year she received a small action research grant from the Lemelson Foundation to work with the InvenTeam records and to engage the teacher and the student historian in reflecting and helping outsiders understand the processes, practices, and networks of support the InvenTeam had and needed. The third author of this paper was a research assistant during this second study and participated in Zoom-enabled video interviewing of the teacher and the student historian and in the analyses of the data. As noted above, for this paper we draw primarily on the records from the InvenTeam year, with insider explanations added, when necessary, from the second archive of Zoom interviews.

## Analyses

IE principles of nonlinearity, setting aside ethnocentrism, noting boundaries, and making connections guided our examination of the data to demonstrate how adult mentors and high school students interacted to develop ideas for solving a design problem students encountered in creating an invention prototype. Given that IE is an ethnography and focuses on longitudinal cocreation of languacultures-in-the-making, our first analytic step followed the making connections and nonlinearity of ethnography principles and led us to constructing an event map of the major activities over time.

Then, following the nonlinearity principle and exploration of rich points to uncover cultural practices as coconstructed through language and actions of the insiders, we focused on April 26th, 2019. This day included a technical mentor working with and ultimately rejecting a student's idea, which created the rich point and anchored our desire to understand why the previous practices of supporting student ideas seemingly were broken. Setting aside our perspectives, or ethnocentrism, of the second ethnographic principle, we sought to understand what happened, how, and why through insider points of view. We summarized the video records and created an event map for the anchor day. Identification of the rich point followed the nonlinearity as well as the boundaries principles and was step two in our analytic process.

Step three involved identifying in-time event boundaries as signaled by insiders within the larger boundary for the cycle of inquiry. For this step, we constructed transcripts and engaged in discourse analysis to examine how the rich point was constructed and what it meant for insiders. The principle of making connections informed our step four in the analysis and helped us show how the rich point was connected to prior and subsequent events and interactions through which the members of the InvenTeam, along with the teacher and technical mentors, progressed toward their ultimate goal of developing a working prototype and presenting it at MIT. In the next section we demonstrate analyses constituting each of these steps, though the analyses and explanations are partial, due to space limitations. Our main goal is to demonstrate how an IE epistemology guides analyses at multiple levels of scale and helps uncover complex in- and over time processes of inquiry-based interactions in context.

### Step 1. Event Mapping Over Time

To understand what the InvenTeam engaged in over the span of the project, we constructed an event map for the InvenTeam year. Event maps represent main activities through which the languaculture is being created and work is getting accomplished over time (Green & Bridges, 2018). Year- and month-focused event maps provide the big picture and set the context for deeper explorations of when, and what, takes place within the group (Kelly & Green, 2019). Figure 1 is an event map for the 2018-2019 InvenTeam year separated by month. In the last segment of the timeline, we also mention 2020, to mark the beginning date for the project with the teacher and student historian and to demonstrate the continuing learning, reflection, and engagement in understanding the processes and practices that occurred during 2018–2019.

The main events in Figure 1 represent summaries of the key activities occurring that month. Some of the events, such as "working on cups," occur over multiple months, demonstrating the iterative and longitudinal process of project- and problem-based work toward a common goal. Shaded in a different color is one particular event in April we analyzed further to explore how adult mentors facilitated the work of high school students engaged in inventing a prototype solution for a real-world problem. We chose this event because it relates to our focus on mentor-student interactions and because it is in the middle of two events focused on students working on the cups and thus engaged in design thinking and problem solving. We wanted to understand in what ways

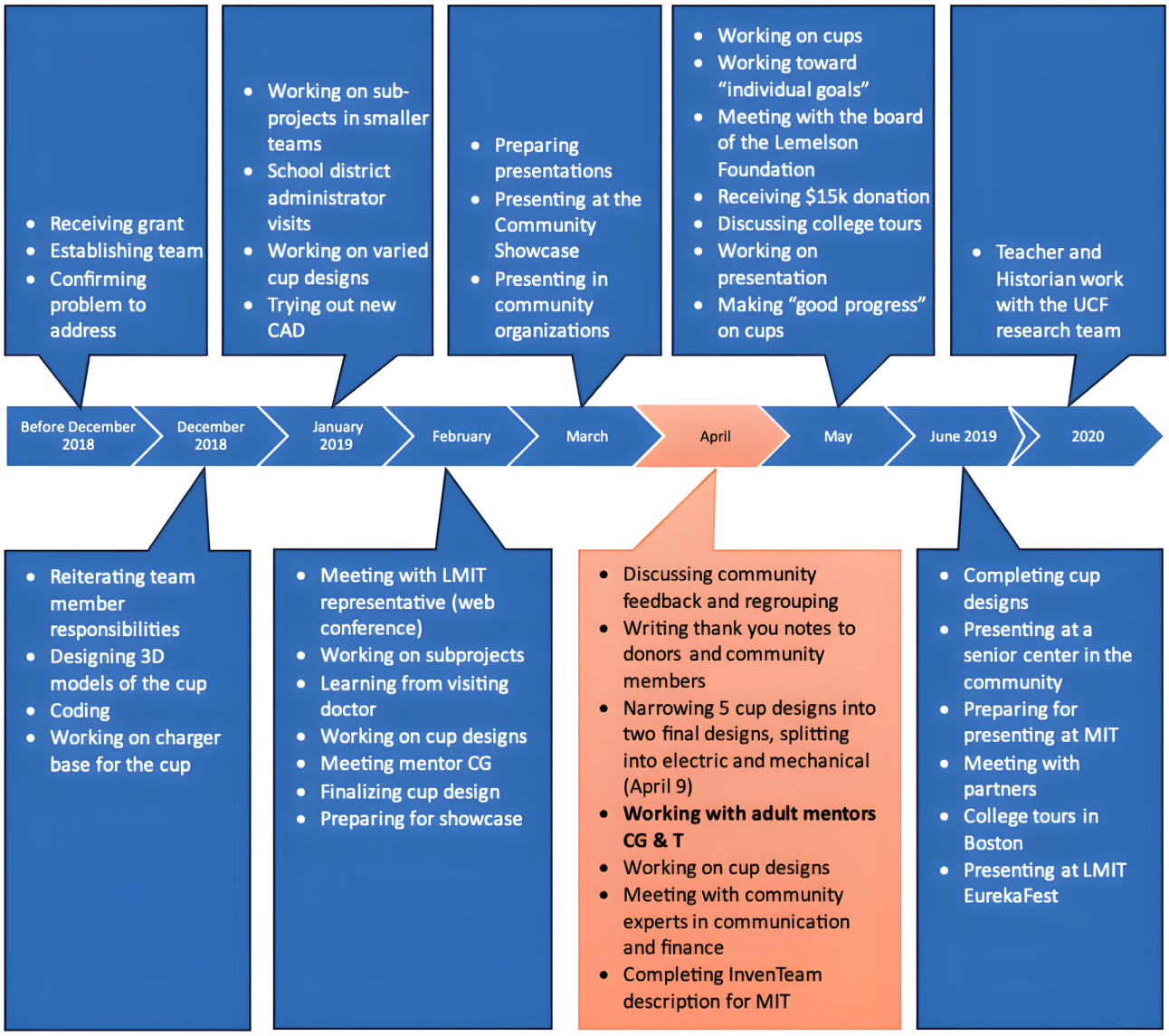


Figure 1. Event map over the years 2018–2020

mentor-student interactions shaped the inquiry-based learning processes. Returning to archived videos and transcripts, we identified April 26 for further examination. It was the day when mentor CG actively worked with the students, mentor T was present, and students explored, questioned, and proposed ideas for solving the problem they encountered in designing the cup.

### Step 2. Identifying an Anchoring Rich Point

Once we identified April 26 as a day for further analyses of mentor-student interactions in PBL processes, we selected the three videos available in the archive for that day. Each of the videos were 33 minutes in length (we do not know why the student historian or her team members chose to stop/restart the videos at those intervals). Following the IE principles of setting aside ethnocentrism and identifying boundaries based on the actions and perspectives of insiders, we first rewatched the videos, (re)familiarizing ourselves with the records and constructing a summary of what occurred in each video. Through this summary of what occurred in each video, we sought to gain an overall picture of the day and summarize it in a way that captured the essence of the day to ground further analyses.

The summary of the events in Table 2 gives an overview of how from the beginning of the day's events as captured in video 1, mentor CG asks students what they want to learn and how. With the prompts and support of mentor T, the students and mentors engage in brainstorming solutions for the

| Video # | Summaries of videos from 4/26 |
|---|---|
| 1 | T tells students technical mentor CG will teach Arduino coding; CG asks what else they'd like to learn. Students indicate gears. T prompts students to identify problems that didn't work. Students are problem solving and brainstorming solutions with mentors CG and T. Discussion about the hardest problems to tackle. |
| 2 | Discussion of process, decisions, and why they need to be able to talk about things. CG emphasizes the ability to talk about the process and things students have learned. T proposes design sprint or using CG to learn technical stuff. CG gets his new nickname. Students decide to work on the new cup design. T opens the computer lab. |
| 3 | CG stands at white board and works with students on the cup designs. Discussion about finger grips starts at 2:57; at 5:56 CG repeats back what L is suggesting to ensure his understanding; L clarifies. T offers an explanation of technical aspects of the mechanics. CG gives L a word for what she's talking about but explains why it doesn't fit in this design. Side conversations. 13:35 CG explains his drawing on white board (board off camera). CG converses with students about handles/magnets in relation to student C's idea when Ir interrupts. M facetimes with her ideas, Ir and X show to M what is on the board and try to explain while T takes lunch orders. |

Note. Mentors: T & CG; students: Ir, X, J, L, C, and M (on FaceTime)

Table 2. Summary of Video Records from 4/26

problem they are facing in their cup design process (designing a handle for the cup). In video 2, mentor CG emphasizes the importance of talking through the ideas and mentor T offers students two options. One option is a design sprint to work on the design of the cups, and the other is to have CG offer any technical help the students may need. The students make the choice to work on the cups, and in video 3 we see them working with CG to identify, understand, and propose solutions to the cup handle design problem students are facing. Approximately 23 minutes of this video—made visible in Table 2 through the video's time stamps—focuses on mentor CG engaged with student Lynn (L; pseudonym) who offers an idea and works on explaining it. In the end, her proposed solution is rejected as a "good idea" but unfit for the team's current design.

Mentor CG rejecting Lynn's idea created a rich point (surprise) (Agar, 2006) for us since it contradicted previously established norms for the group and the role of the mentors. As the teacher explained to us in the Zoom-enabled interviews in 2020, when mentors came in to work with her students, she expected the mentors to follow student ideas even if student ideas were not good and would lead to failure of that particular design. The teacher explained that she valued productive failure and the learning that occurs when something does not work. In the previous InvenTeam videos, we have had multiple examples of how the mentors supported student ideas even if they knew the ideas may not work, giving students time to explore, try, fail, and learn in the process. The teacher and the mentors had emphasized the student experiential learning of problem-solving skills and engineering design processes (Skukauskaitė et al., in press). This rich point of the mentor rejecting a student's idea led us to delve deeper into examining interactions of this exchange captured on video 3.

We viewed the video again and utilized the transcript from the day to construct a more detailed event map for the events captured on video 3. (We describe the construction of the transcript in step 3. Our use of it for step 2 also indicates

| Event | Time | Events of video 3 |
|---|---|---|
| 1 | 1:17 | CG reiterates a problem with handles students had previously identified |
| 2 | 1:47 | Conversation shifts to names and nicknames |
| 3 | 2:27 | CG refocuses on the handle and students discuss don't love/don't hate votes on the ideas |
| 4 | 3:50 | Students try out different words and ideas: bumps, grips, lumps |
| 5 | 4:04 | L offers and explains the grips and squeeze idea |
| 6 | 5:11 | One student leaves, others wish her a good day |
| 7 | 5:31 | CG repeats L's idea to "make sure I got it right" |
| 8 | 6:02 | L denies CG's interpretation and continues explaining, CG encouraging her to continue |
| 9 | 7:09 - 7:43 | T explains how the cup design they are currently working with uses a different mechanism than what L is suggesting;<br>CG marks L's "actually a really good idea" but notes that it "fights with this design a little bit" |
| 10 | 8:02 | CG and L interact to understand why the idea doesn't work and CG tables the idea for later conversations with L |
| 11 | 8:31 | CG reiterates the smaller diameter, handle, and disk components for the design |
| 12 | 8:59 | Student Ir offers the solution of having the handle fixed to the disks |
| 13 | 9:25 | Students and CG discuss pros and cons of Ir's handle design; students compare the design to a Yeti cup; CG indicates he doesn't know what a Yeti cup looks like, which students explain and CG agrees "I will take your word for it" |

Table 3. Events of Video 3 from 4/26

the iterative and recursive processes of data analyses in interactional ethnographic research). Table 3 includes an event map for video 3.

The interaction begins with mentor CG reiterating where the team is at in the design of the cup and reminding them of the problem (events 1–4). Events 2 and 6 are marked in red since they were conversations not related to the cup design, though they do indicate languacultural norms of the community the members of the InvenTeam had built (friendly teasing and respect in event 2 and well-wishing and flexibility for participation in event 6). For the purposes of this paper, we focus on the remaining events, with events 5 and 7–10 constituting our focus rich point.

In event 3, students discuss what they "don't love/don't hate" about the ideas previously generated in video 2, and in event 4, students explore different ideas for the handle. In event 5, Lynn offers an idea of grips that a user could squeeze to regulate the flow of liquid in the cup. In event 7, mentor CG reiterates Lynn's idea, indicating he wants "to make sure I got it right." In event 8, Lynn rejects CG's interpretation and continues explaining her idea, with CG's encouragement. However, in event 9, CG indicates that the idea does not work with the team's current design even though the idea is good. In event 10, Lynn and CG engage in an interaction about why Lynn's idea doesn't work, ending with the mentor tabling the idea for their further conversations. In event 11, mentor CG reiterates the components of the cup design the team had already chosen, student Indra (Ir; pseudonym) offers a different idea for the handle (event 12), and video ends with students and mentor discussing pros and cons of Indra's idea and attempting to envision the design by comparing it to a Yeti cup, with which CG is unfamiliar and decides to accept student perspectives.

Throughout these 13 events captured on video 3, the students and the mentor are actively engaged in interaction about ways of solving the handle problem for the cup they have been designing. The conversation is friendly and various students offer ideas and responses. Lynn offers a substantial idea, which the mentor seeks to understand and eventually rejects as a good idea but unfit for the team's design. In rejecting it, the mentor opens an invitation for Lynn to talk with him about the idea further at a later time. Lynn's idea is set aside, and other students continue to engage in offering other solutions for the handle problem.

Drawing on the ethnographic principle of identifying connections, we noticed how events 1–4 and 11–13 connected to show how the students and the mentor focused on collective ideas for the cup design the team had already settled on. These two sets of collective-focused events created a boundary for events 5 and 7–10 in which a single student offered an idea, but the idea was not appropriate for the team's design and therefore was rejected. To understand how this collective focus on ideas feasible for the team's cup got constructed through interactions, we needed the next level of analysis—constructing a message-unit level transcript and engaging in discourse analysis of the interaction.

However, before we demonstrate the next analysis, we need to draw on ethnographic principles of setting aside ethnocentrism, making connections, and nonlinearity to explain Lynn's position on the team and offer a contextual interpretation of CG's response. Outsider ethnocentric perspectives may lead people to evaluate the male mentor CG's interaction with female student Lynn as imbued with power and gender dynamics. However, based on longitudinal analyses of the video archive, the interviews with the teacher and the student historian, and Lynn's own narrative of her life story in another study, we know Lynn had the most extensive engineering experience of the students on the team, had been instrumental in choosing the dysphagia problem, and had led the cup design and many of the technical solutions to the team's design questions. While soft-spoken and somewhat shy, she and mentor CG interacted extensively around engineering and design ideas from the very first day the mentor had entered the team in February. By April 26 analyzed here, the mentor, Lynn, and other students on the team had a good rapport and had also engaged in many conversations about the need to brainstorm, try out, and reject ideas to move the invention process forward. These histories may not be visible in the moment of the interaction but are part of the ethnographic knowledge of being there (Hammersley & Atkinson, 2019) and the nonlinear, interconnected, insider-focused understandings of this particular InvenTeam's languaculture.

**Step 3. Constructing a Transcript and Engaging in Discourse Analysis**

The summary of videos from the anchor day and event mapping of video 3 helped us identify the rich point in the interaction between mentor CG and student L. As interactional ethnographers seek to understand in depth not only what happens but also how it is constructed in and through the language, interactions, and actions of the members of the group, we needed to zoom in on the rich point for deeper analyses. To enable more nuanced analyses, we needed to transcribe the segment of the video which included the rich point. Transcribing in IE is purposeful, theoretically informed, and involves creating a transcript appropriate for the IE purposes of in-time and over time analyses (Skukauskaitė, 2012, 2014). Interactional ethnographers start in-depth analyses with message-unit level transcripts. Message units (MU) are bursts of speech marked by contextualization cues, such as micropauses, inflection, movement, or speaker or topic changes, among others, enabling the researcher to determine how meaning is being constructed moment by moment during the interaction as speakers signal meaning to the present and implicated listeners (Green & Kelly, 2019; Green & Wallat, 1981). MUs interconnect into action interaction, information, sequence, and other increasingly larger units of scale, making connections among discursive actions and meanings in the moment and over time (Green & Kelly, 2019; Skukauskaite, 2014). Discourse analysis of MU grounded transcripts helps interactional ethnographers understand how insiders construct meanings as they discursively signal the boundaries of what is culturally and socially significant for the group and its interactions.

Event 1 of Table 3 begins with CG iterating where the team was at in their design of the cup. Table 4 represents this initial interaction. To conserve space, for this analysis we combined a MU transcript into lines that represent information units (IU; Skukauskaitė, 2014; Skukauskaitė & Girdzijauskienė, 2021), which are combined message and action units that form a particular unit of information being conveyed. The MUs, as originally transcribed, are marked by forward slash (/). Student discourse is italicized.

In IU 1–5, CG iterates what the team has already accomplished (IU 1) and what they agreed needs to be done next (IU 2–3) and invites any objections (IU 4), while delimiting space for the conversations about the cup at this time (5). In IU 6–7, he reiterates what is to be done (connecting to ideas in IU 2–3) and leaves students with an option of how they can accomplish it ("whether it be threaded or pressed or whatever"). In this first sequence (IU 1–7), CG constructs an overall picture of where the team is at in their design and work on the cup. By using "we" throughout his discourse, he

| IU | Speaker | Discourse | Information conveyed |
|---|---|---|---|
| 1 | CG | alright / so / the easy one's the cup / right | Shifting conversation, iterating what has been accomplished collectively |
| 2 | | because at this point we basically are just gonna shrink it down a little bit | Reiterating agreement "we" have reached collectively |
| 3 | | and we're not gonna put anything on the inside / just yet / right | Adding agreement about the inside of the cup not changing yet |
| 4 | | so / any / any objections to just kinda like | Calling for objections to what was agreed upon |
| 5 | | not / we'll not talk about the cup too much | Iterating that conversation about the cup part was finished for now |
| 6 | | the only thing that we have to worry about with the cup is that it fits / the disks and the handle and the lid | Reminding the task to be done—ensuring the parts fit together |
| 7 | | so whether it be threaded or pressed in or whatever | Reminding there are options in how to accomplish the task |
| 8 | *Ir* | *should I start with literally just the base* | Asking a question |
| 9 | | *and get the threading to fit each other and be the same size / and then add to it* | Explaining her intended process |
| 10 | CG | you could / but not quite yet / but that's the right idea | Approving idea but suspends it |
| 11 | | right / the only thing that really matters is how it interfaces with the next level | Providing the larger purpose for this step, reiterates design |
| 12 | *Ir* | *right* | Agreeing |
| 13 | CG | right / now / but we did have a / actually / we did have a problem / we haven't decided | Transitioning to a more pressing problem with no decision |
| 14 | *Ir* | *[xxxx] / [xxxx]* | Inaudible, overlapping with laughter |
| 15 | CG | laughs) / we have / we haven't really decided where the handle's gonna go | Reminding the communal "we" problem about the handle |

Table 4. Event 1 (From Table 3). Encompasses MUs 2–47 in Transcript

| | | | |
|---|---|---|---|
| 16 | *Ir* | *yeah* | Agreeing, recalling |
| 17 | CG | right / is the handle gonna be fixed to the cup / is it gonna be part of the disk assembly | Reminding of previous ideas and asks question with options |
| 18 | | we don't know the answer to that question yet / alright | Iterating "we" don't the answer "yet" |
| 19 | *Ir* | *mhm* | Pondering |
| 20 | CG | so / what do you want to do about it | Inviting ideas |
| 21 | *Ir* | *what do you guys think* | Reiterating invitation, addresses the team "you guys" directly |
| 22 | CG | taking comments | Opening for comments |
| | *All* | *(joking about who's listening and not, about names and ways to pronounce them)* | |

*Note.* [xxxx] indicates speech we could not decipher or the masking of identifiable information; speech is transcribed as heard and not transformed into formal English (e.g., gonna); (parentheses) indicate our summary or notes of nonverbal cues.

Table 4 continued. Event 1 (From Table 3). Encompasses MUs 2–47 in Transcript

signals that the accomplishments and agreements are collective and that he is following their decisions. When in IU 8–9 Indra asks a question about what she could do to finish up what has already been done (referent to IU 6–7), CG approves her idea but suspends it, stating "not quite yet," and reminds her that the parts need to "interfac[e] with the next level." Here, he reminds students of not only their accomplishments and tasks, but also the engineering design processes.

In IU 13, CG reminds the team "we did have a…actually... we did have a problem we haven't decided" regarding where the handle on the cup will go. In the sequence consisting of IUs 13–18, he continues to iterate "we" as a collective and helps the team refocus on the "undecided" problem rather than those they have already agreed upon, as in IU 1–12. In IU 20, he invites student ideas and actions, asking "what do you want to do about it." In IU 21, Indra reiterates CG's invitation to brainstorm and share their thoughts, while at the same time taking over the ownership of the process, relanguaging the invitation in her own words, and addressing it to her peers as "you guys".

The next events, as represented in the previous Table 3, include an off-track joking conversation about names and not listening, and refocusing on the handle design. In event 3 (Table 3), CG helps refocus the students on the handle problem, to which students brainstorm ideas, share which of the generated ideas they "love/don't hate" and, in event 4, continue offering ideas of grips, lumps, and bumps as potential solutions to the handle design problem. Event 5, which we identified as the start of the rich point, begins with CG reiterating "so we are literally in a handle situation," Indra agreeing, and Lynn then offering her idea about grips. Table 5 includes the MU transcript of the event 5 exchange in which mentor CG, along with student Ir and mentor T, facilitate Lynn's explanation of her idea.

This exchange starts with mentor CG reminding the team that "we are in the handle situation" and they need to find solutions to the handle problem for the cup (MU 185). Lynn offers the idea "I kinda want the grips," and Indra facilitates further explanation by asking "could you explain?" Mentor CG asks, "the lumps?," referencing the prior brainstorming among students (MU 190--192); Lynn offers, "like the squeeze," and CG initiates his emerging understanding of her idea, "oh the squeezy grip?" Here the question mark indicates a rising intonation pattern and, unlike a statement, offers an open door for further exploration (MU 193--194). He then explicitly invites Lynn to "explain / come / bring it up / come on / don't shy away / talk to me / talk to me." Through these seven different iterations of the invitation for Lynn to explain

| Speaker | MU | Discourse |
|---|---|---|
| CG | 185 | so we are literally in a handle situation |
| *Ir* | *186* | *yes* |
| CG | 187 | okay |
| | 188 | so |
| | 189 | sorry you got overruled (to Ir) |
| L | 190 | I kinda want the grips |
| *Ir* | *191* | *could you explain* |
| CG | 192 | the lumps? |
| *L* | *193* | *like the squeeze* |
| CG | 194 | oh the squeezy grip? |
| | 195 | explain |
| | 196 | come |
| | 197 | bring it up |
| | 198 | come on |
| | 199 | don't shy away |
| | 200 | talk to me |
| | 201 | talk to me |
| *L* | *202* | *I think* |
| | 203 | *just because h-* |
| CG | 204 | like a [xxxx] |

Table 5. Mentor Facilitating Student Explanation of Her Ideas (MU 185–244 of Video 3)

| | | |
|---|---|---|
| *L* | *205* | *that way it's easier for them to be tilted* |
| [Off camera] | 206 | [shh] (to others) |
| *L* | *207* | *they don't have to go all the way* |
| *Ir* | *208* | *okay* (response to [shh]) |
| *L* | *209* | *you know how you have maybe like* |
| | *210* | *one of those water bottles* |
| | *211* | *and you're trying to get to the last bit of water* |
| CG | 212 | uh huh |
| *L* | *213* | *and you can't* |
| CG | 214 | uh huh |
| *L* | *215* | *imagine that but* |
| | *216* | *not being able to swallow* |
| | *217* | *and then a whole bunch comes into your mouth* (pause) |
| *Ir* | *218* | *what does the grip have to do with that?* |
| T | 219 | what part is squeezing? |
| CG | 220 | yeah I'm listening |
| *L* | *221* | *like* |
| | *222* | *like* |
| | *223* | *it would like* |
| T | 224 | oh the bottle squeezes |
| *L* | *225* | *like when you squeeze the* |
| | *226* | *the water* |
| CG | 227 | like a capri sun? |
| *L* | *228* | *no* |
| | *229* | *it's more like* |
| | *230* | *not like that* |
| | *231* | *I was thinking more like* |
| | *232* | *if you* |

Table 5 continued. Mentor Facilitating Student Explanation of Her Ideas (MU 185–244 of Video 3)

| | | |
|---|---|---|
| | *233* | *when you squeeze it* |
| | *234* | *like you guys were talking about the water bott-* |
| | *235* | *the sports water bottles* |
| CG | 236 | uh huh |
| *L* | *237* | *and how it* |
| | *238* | *like* |
| | *239* | *they could have something at the bottom* |
| | *240* | *that could go up with it* |
| | *241* | *and I was thinking something like that* |
| *Ir* | *242* | *so* |
| CG | 243 | I get what you're saying |

Table 5 continued. Mentor Facilitating Student Explanation of Her Ideas (MU 185–244 of Video 3)

her idea, CG opens the space for Lynn to expand on her idea (MU 195--201). She begins hesitantly, "I think / just because h-," aborts her thought (indicated by the aborted word "h-"), offers a comparison, "easier," and continues to offer a defense for her idea "just because […] / that way it's easier for them to be tilted / They don't have to go all the way;" she compares her idea to a water bottle issue that most members of the group have encountered (MU 202--207).

Lynn continues the explanation by first creating a common and familiar ground through the example of the water bottle (MU 209--213), then evoking empathy for people with difficulties swallowing (MU 215--217). When Indra challenges her explanation with "what does the grip have to do with it?" (MU 218) and mentor T asks, "what part is squeezing?" (MU 219), mentor CG overrules the challenges at this point, indicates, "I am listening" (MU 220), and maintains the space for Lynn to continue her explanation. As she proceeds, mentor T expresses his emerging understanding "oh the bottle squeezes" (line 224), indicating his engagement with Lynn's train of thought and comparisons to the water bottle, while mentor CG offers a different comparison, "like a Capri Sun?" (MU 227).

The different ideas offered to ensure the listeners understand Lynn's idea lead Lynn to reject their ideas and assert her "no" (MU 228). She then offers a more precise comparison to a sports water bottle, not just any water bottle, and how the sports bottle idea could be modified to show her idea for the cup. In MU 242 Indra begins with "so," but mentor CG steps in, managing the interactional space with "I get what you are saying" (MU 243), affirming Lynn's explanation process and her right to use the InvenTeam conversational space to explore ideas with team members and mentors.

Discourse analysis of this segment demonstrates how ideas are being brought into an inquiry space and how invitation, listening, and attempts at expressing understanding by mentors and peers enable a young inventor to work on articulating her ideas by relating the ideas to known objects, invoking empathy, and asserting her stance. The facilitators are a peer and two mentors who listen and attempt to follow Lynn's idea without judgment, creating space for explanatory and reflective articulation and learning. CG as the primary facilitator encourages idea development; however, Lynn's idea ultimately gets rejected, creating a rich point (Agar, 2006; Skinner, 2023) for us as researchers. To understand how and why it happened, we drew on the ethnographic principles of making connections, identifying boundaries of meaning within participant discourse, and setting aside our perspectives and knowledge to understand what happens and what it means for people in the group.

**Step 4. Making Connections**

In our analysis of events represented in Table 4, we made visible how the mentors and students created a collective "we" and a collective set of understandings of what was accomplished and what needed to be done for the cup. When Indra shared her idea of the next steps for the cup design, she positioned her idea within the team's current understanding and goals of "start[ing] with literally just the base / and get[ting] the threading to fit each other and be the same size and then add[ing] to it" (IU 8–9 in Table 4). Mentor CG told Indra "that's the right idea" but not yet, since the team needed to get to the "next level," which was the problem of the handle design. In Table 5 we presented discourse analysis of how Lynn introduces her idea for the "handle problem" and how CG, with participation from Indra and mentor T (and other students present but not talking), creates an interactional space for Lynn to develop her idea.

However, as the conversation continues and Lynn develops her idea further, it gets rejected. In the MU transcript excerpt represented in Table 6, we present the interaction in which the mentors indicated their understanding of Lynn's idea, evaluated it as "good," but tabled it because it did not work with the team's design. Table 6 includes the MUs from the transcript, the speaker, and analysis of what the speakers accomplish through the conversation (discursive actions column). The last column indicates connections we saw analytically by following speaker discourse and considering the IE principle of making connections. Due to the word limits for this article, we will highlight a few of the segments from the table rather than provide a full interpretation. We invite the reader to follow the IE principles we presented above and our analytic notes in the last two columns to construct their own interpretations and check ours.

In MU 262–264, mentor CG acknowledges Lynn's idea as good, but in the next utterances states "we" are "going down a certain route right now." In this juxtaposition of "good idea" and "certain route," CG indicates that there are multiple paths to the solution of the problem, and the path Lynn has chosen is "down" a certain route. Here he makes connections to engineering design processes and multiple problem-solving routes the team had discussed earlier in the year (not presented in this paper but see Skukauskaitė et al., in press) as well as the purpose for the cup the team had established. The purpose is implied here through the discursive use of "we," "route," and "right now." In MU 267, Lynn acknowledges CG's guidance and takes a listener and student stance, connecting to her role on the team. In the next sequences (MU 272–277), CG positions himself as learner and reiterates Lynns's idea to make sure he understood. Here he positions himself as a listener and learner, and Lynn as a guide and expert of her idea. The connections made are to their roles as InvenTeam mentor and member, respectively, as well as to the invention processes of seeking and getting feedback to ensure common understanding. The discourse used ("you're thinking"; "squeezy bowl"; "pumping water") also connects to Lynn's and the team's previous ideas and conversation. Implied in the discourse is also the knowledge of physics and mechanics (flow of water, pump mechanisms).

In rejecting CG's understanding with a strong "no," Lynn asserts her position as an InvenTeam member and originator of the cup's idea and connects to the prior conversation and her prior "no[s]" (as visible in analyses above). In MU 279–281, CG accepts her leadership, repositions himself as a learner, and invites further explanation, thus reiterating the interactional explanatory spaces created among Lynn, the mentors, and the other students on the team. At this point mentor T offers his interpretation, which Lynn also rejects. CG and T take on the listener roles, accept their responsibility for not understanding, and invite Lynn to continue explaining. This interaction connects to this InvenTeam's languacultural patterns in which student ideas are given priority while mentors support and guide the students, not tell them how to create or implement their design.

As Lynn continues her explanation with CG and T listening (MU 292–327), the student-led interactional problem-solving space remains open. However, in MU 328–332, mentor T takes the floor and redirects the focus of the conversation from Lynn's idea to what "the people were thinking." In this way he foregrounds the team and the team's invention of the cup. He also alludes to the prior conversation about the goals for the day and the "handle problem" the team needed to solve. With an "oh" in MU 333, Lynn realizes this shift, opening the space for understanding the two mentors' explanation of how the team's cup does not work the way Lynn is envisioning. In this way, the mentors are making connections to the team's goals while also both reminding and teaching the engineering knowledge and vocabulary ("actuate", "flow", "ball valve"). The use of technical terms connects to Lynn's and the team's earlier dialogues about ball valves (not analyzed in this paper) and the technical knowledge the students have been developing when designing and building a cup prototype. In MU 345, CG offers the name for the idea Lynn was developing, "metering;" Lynn acknowledges it matches what she meant (MU 350) and CG explains what the technique does and where it is used. In this dialogue, they make connections not only to the team's cup design and the needs of the team, but also to engineering knowledge, language, and medicine as a field in which Lynn's proposed idea has been implemented. In naming the "metering" technique, CG explains that metering "fights with this design a bit" and does not fit the team's goals or cup design.

| MU | Speaker | Discourse | Discursive actions | Connections signaled |
|---|---|---|---|---|
| 262–264 | CG | so (pause) / hold that thought/because it's actually a good idea | Affirms "good idea" | Previous statement |
| 265–266 | | except / that we're already going down a certain route right now | Marks multiple possible paths | Multiple routes; Design processes; Purpose |
| *267* | *L* | *okay* | *Takes student, listener stance* | |
| 268–271 | CG | um / because / so you're thinking / (sigh) | "You" positions her lead | L's previous articulation |
| 272–274 | | let me / let me / let me repeat what I understand you're talking about to make sure I got it right | Positions himself as learner/listener | L's previous idea; Understanding of the problem, proposed solution, and the perspective of the speaker/user as key in invention |
| 275–277 | | you're thinking / something like a little squeezy bowl? / so it actually pumps the water out? | Positions her thinking as a foundation for the conversation; Reiterates his understanding of her idea; Rising intonation keeps the space open for L to continue | L's previous idea; Understanding of water movement and physics (implied) |
| *278* | *L* | *no* | *Denies CG's interpretation, asserts her position* | *Prior nos to other interpretations that didn't work* |
| 279 | CG | okay | Accepts her lead | |

[3] Here, some MUs are combined into action units demarcated by horizontal lines between numbers and number-ranges in the MU column and extended across columns 3–5. Forward slash (/) indicates MU boundaries.

Table 6. Transcript Segment MUs 262–450 .

| | | | | |
|---|---|---|---|---|
| 280 | | go at it again then | Requests further explanation | Same previous idea, but new explanatory space |
| 281 | | because apparently I missed it | Positions himself as a learner and "missed" understanding as his responsibility | L's prior explanation; Team's prior conversations about roles of mentors (implied) |
| *282* | *L* | *okay so* | *Takes the lead in explaining* | |
| 283 | CG | I'll get to you in a second | | Students at another table |
| 284 | T | you're just saying if it's a little squeezy then you can hold it better | T offers his interpretation; T takes over for CG as he engages with another student | Prior conversation and explanation about "squeezy;" Collaboration between mentors |
| *285* | *L* | *no* | *Takes a stance* | |
| 286 | CG | is that right? | Rising intonation maintains open space | Prior conversation and interactional space |
| *287* | *L* | *no* | *Reaffirms her stance* | *Prior nos in the preceding interaction* |
| 288–291 | CG | see we're / we're both missing it / alright so L [xxx] / go ahead don't be shy | Accepts responsibility for their not understanding; Invites L to continue explaining | Mentor roles on the team; Relationship and knowledge of L as "shy" |
| *292* | *L* | *okay so* | *Engages in further explaining* | *Prior explanation* |
| 293–327 | *CG & L* | *L continues explaining her idea, with CG mainly listening* | | Student as guide expectation for the mentors coming to InvenTeams |

Table 6 continued. Transcript Segment MUs 262–450 .

| | | | | |
|---|---|---|---|---|
| 328–332 | T | so / I think the way that people were thinking about this cup is that / it just slows down the flow / it doesn't actually / just release a certain amount of water | Takes floor; Repositions focus on "people" | Team's "thinking" and intention for the cup's design; Engineering knowledge |
| *333* | *L* | *oh* | *Acknowledges, realizes the connection proposed* | *(implied connection to team)* |
| 334 | T | right so | Accepts L's realization; takes floor | Mentor position |
| 335 | CG | so | Attempt to take floor | |
| 336–338 | T | it doesn't actually / actually open and close / and actuate in that way | Reminds the way the cup works/doesn't work | Technical solutions and capacities of what the team has designed; Mentor role as more knowledgeable other |
| 339 | CG | so yeah | | |
| 340–342 | T | just like the ball valve / like it just makes it so you get a / a slower flow | Explains technical design | Ball valve discussion with L and the team; Engineering, mechanics, physics knowledge |
| *343* | *L* | *oh okay* | *Acknowledges* | |
| 344 | T | and I think that's kind of what they're | Reiterates team's design | Team's idea(?) |
| 345 | CG | the technique that you're referring to is called metering | Names and explains the technique in detail | Engineering knowledge and language |
| 346–349 | | CG explains the technique | | |
| *350* | *L* | *yeah* | *L acknowledges it's what she meant* | *L's understanding of engineering* |

Table 6 continued. Transcript Segment MUs 262–450 .

| | | | | |
|---|---|---|---|---|
| 351–357 | CG | um / it's actually a really good idea / for / dispensing a very precise amount of liquid / and that's what they use for medicine / and stuff like that | Positioning of L's idea as good; Connecting to another field | Medicine; Knowledge of physics |
| 358–362 | | but / what I will say is that / that makes for / particularly / it kind of fights with this design a little bit | Juxtaposes "good idea" with "this design" | Team's goal and design |
| *363* | *L* | *yeah* | *Acknowledges* | *Learner stance* |
| 364–365 | CG | right / it's kind of a different mechanism | Emphasizes difference in mechanism, not idea in itself | Mechanics; L's experience/ understanding of engineering |
| *366* | *L* | *yeah* | | *Learner, listener stance* |
| 367–368 | CG | so it's a good idea but it kinda doesn't fit into this conversation / but hold that thought cause we will get back to it | Acknowledges and rejects the idea; Foregrounds future talk | L's idea, team's goals and design; Future conversations |
| *369* | *L* | *okay* | *Acknowledges* | *Learner stance; Team membership* |

Table 6 continued. Transcript Segment MUs 262–450 .

As Lynn acknowledges this (MU 363), CG leads Lynn to the conclusion that her idea "is a good idea but it kinda doesn't fit into this conversation." In rejecting the idea for the immediate needs of the team, CG keeps the door open to future conversations and asks Lynn to "hold that thought cause we will get back to it."

Through this analysis of the speakers' discursive actions and stated or implied connections, we noted varied layers of connections signaled in the conversation. The ethnographic principle of making connections as well as the principle of identifying boundaries, based on what the speakers say within the immediate and larger flow of their everyday life, led us to explore what is relevant for the speakers in the moment and how they create contextualization (Skukauskaitė & Girdzijauskienė, 2021) for their immediate and delayed actions (Bakhtin, 1979/1986). Here connections were made to immediate prior interactions, interactions that had happened much earlier in the group's work together, the varied roles of the speakers, the collective team and its goals, as well as the different disciplinary fields and knowledge.

## Discussion: Affordances of IE Synthesized

As demonstrated in the presentation of layered steps of empirical analysis above, an interactional ethnographic lens enables the uncovering of complex processes of learning moment by moment and over time, in specific languacultural

groups, and in varied configurations among participants of the group studied. In our focus on interactions among a high school student, her team, and the technical mentors engaged in IvE, we demonstrated how a particular moment, such as the rejection of a student's idea, needs to be empirically grounded and understood in the developing languaculture of the group, in this case, the InvenTeam. Through tracing student and mentor interactions moment by moment and over time in context, we made visible how people create spaces for each other to develop their ideas and how the ideas can be repositioned and rejected not as a personal rejection, but as something that does not work for the collective and the larger goals of the group's languaculture. Understanding what happened, why, and what the moment of rejection meant for the individual and the collective involved tracing the discourse of preceding interactions, the design of the learning opportunities, the team's prior goals and decisions, and the multilayered curricular and interpersonal contexts shaping the ways the students and mentors interacted as they worked on coming up solutions to a problem of designing an adjustable flow cup to help people with dysphagia. The IE lens enables us to uncover and represent the multilayered complexities and pathways of how moment by moment and over time interactions shape learning opportunities. The discourse is about both the moment and the larger goals and processes of the languaculture as a group of students engaged in PBL.

In summary, IE enables the educational ethnographer to study a wide range of learning contexts along the inquiry-based continuum (Jonassen, 2000; Savery, 2006). IE as an epistemology provides a systematic and transparent methodological framework for the educational ethnographer to undertake studies at multiple levels of scale. It is fundamentally empirical (Heap, 1995), as it is grounded in systematic collection and analyses of archived records of learning in situ.

The above example from research in IvE outlines the core principles and the four major steps in designing an IE study and analyzing its records. It illustrates how IE researchers draw on the overarching logic of inquiry to develop systematic and nuanced insights through in-depth analyses of learning moment by moment and over time. The micro-ethnographic discourse analysis within IE supports in-time analysis of how people construct meanings in groups through language-in-use. In the example above, the analysis makes visible how invention educators facilitate this complex process with a group of young inventors. Multilayered analyses also demonstrate how individuals are always a part of a collective (individuals-within-a-collective) and how, to understand what, how, and why something happens and becomes consequential within a cultural group, researchers need to consider multiple perspectives, actions, and interactions at varied moments in the group's developing activities as well as over time (Skukauskaitė & Green, 2023b).

To engage in the multilayered analyses from an IE lens, ethnographers utilize records generated within the study and entered into an ethnographic archive. The range of records and artifacts generated for the archive can include policy and curriculum documents, classroom videos and screen captures of learning events, interview recordings, photographs, participant and researcher reflection journals, to name a few. An ethnographic archive creates an empirical base for analysis. By engaging with archived records, selecting those for focused analyses, and then transcribing the talk and actions of members of the learning community, the IE researcher identifies a telling case and the anchor event(s) which act as a rich point triggering deeper analysis. As illustrated above, by tracing across the ethnographic archive and selecting interrelated records to analyze at increasingly more detailed levels of scale, the interactional ethnographer can examine the roots and routes of educational phenomena, addressing questions such as: How did this event come to be? What were its consequences and for whom? This longitudinal focus on discursively coconstructed consequential progressions (Putney et al., 1999) is one key distinction of IE from other ethnographic approaches that rely on observation more than the languaging processes of the group (Skukauskaitė & Green, 2023a).

## Delimitations and Potential Next Steps into Theory Building

Guided by the IE epistemology and framework, the above example illustrated the core processes of analysis. What we have not engaged in due to the methodological focus for this paper, but a more fulsome IE study would then do, is move into a deeper explanation of how analyses connect to, expand upon, or propose new theories, such as the theories on facilitation introduced above. By engaging with literatures, the IE analyst develops grounded interpretations and deeper conceptual understandings of complex, interactional phenomena. As such, IE supports big picture (zooming out) and over time analyses to gain in-depth understandings of learning as a process in context and as an evolving coconstruction of the group. For example, in Bridges et al.'s (2020) study of PBL facilitation in undergraduate medicine, the team related what was made visible through mapping and ME/DA to theoretical constructs from the learning sciences and semiotics. They then reconceptualised the surfaced, multimodal, technology-infused facilitation processes as "dialogic intervisualizing".

If we were to continue the above IvE telling case to theory-building phases of an empirical IE study, we could expand on invention educators' (e.g., Estabrooks & Couch, 2018) and learning sciences scholars' (e.g., Kapur & Hmelo-Silver, 2018) work on "productive failure" in PBL to more deeply consider how productive failure plays out conceptually in IvE, potentially creating a typology of facilitation strategies. Alternatively (or additionally), given the detailed emic understanding provided by the ethnographic team consisting of university researchers, the teacher, the students, and outside researchers, we could explore Lynn's response in terms of Savin-Baden's (2016) work on threshold concepts in PBL and how these are visible in IvE, and how a facilitator supports students in navigating such concepts. Because IE is not a set of methods but an epistemology with orienting theories about the social and discursive construction of everyday life, it remains open to explanatory theories and varied methodological tools that can shed light to how, why, and in what ways members of a languacultural group act and interact to reach common goals, such as problem-solving in PBL settings or inventing a prototype for a real problem in IvE settings.

## Conclusion

In this methodological paper, we introduced the core underpinning principles and practices of interactional ethnography and, through an example in invention education, illustrated how educational ethnographers engage with the field and delve into the "ethnographic space" to identify key learning processes and develop warranted interpretations (Skukauskaitė & Green, 2023a). As Hmelo-Silver, Bridges, and McKeown (2019) argue, facilitators work from the "fundamental premise that disciplinary knowledge is inherently transitive, fluid, and dynamic," with the group process of collaborative coconstruction eliciting, clarifying and building upon the prior academic knowledge and life experiences of each and every group member (p. 298). By acknowledging the active role of facilitators in the inquiry process, an IE epistemology guides a detailed, empirical study into how they engage their students with the tasks at hand and in meeting their overarching learning goals. We encourage researchers across the range of the inquiry-based learning spectrum to learn and adopt the interactional ethnographic epistemology and engage in deep exploration of discursive inquiry processes in action within and across the iterative and recursive cycles of inquiry.

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## Author Bios

Dr. Audra Skukauskaitė is a Professor of Methodology, Measurement, and Analysis at the University of Central Florida, has taught qualitative research methodologies and research design courses in graduate programs in Texas, California, and Lithuania, has consulted internationally, and has led international seminars on interviewing, ethnography, discourse analysis, narrative research, and academic writing for international publication, among other topics related to qualitative methodologies and research publication. Dr. Skukauskaitė has worked as research contractor and consultant with the Lemelson-MIT program at the Massachusetts Institute of Technology and the STEM Innovator program at the Jacobson Institute, University of Iowa. She has also served as a senior research scientist at Klaipėda University in Lithuania. Dr. Skukauskaitė's interests focus on teaching and learning of research methodologies within and beyond doctoral programs, transparency in ethnographic and qualitative research, invention education, and access to research internationally. Dr. Skukauskaitė has published multiple academic articles and book chapters on ethnography, interviewing, transcribing, the teaching and learning of qualitative research, and transparency in research. Recent volumes include co-edited books on Interactional Ethnography (Routledge) and Engaging Students in Socially Constructed Qualitative Research Pedagogies (Brill).

Susan M. Bridges is an Honorary Professor with the Faculty of Education at The University of Hong Kong and the immediate past Director of HKU's Centre for the Enhancement of Teaching and Learning (CETL) (now TALIC). An award-winning higher education teacher, researcher and curriculum designer, her work is inherently interprofessional and interdisciplinary. After serving HKU's Faculty of Dentistry as Assistant Dean (Curriculum Innovation) she became

Assistant Dean (Learning & Teaching) (tenured) with the Faculty of Education/CETL. Since 2007, her externally-funded research and curriculum initiatives have focused on integrated inquiry-based designs (health professions and teacher education) and how educational technologies can support and enhance these. She publishes widely in these fields and is known for her work in Interactional Ethnography. She is an Associate Editor for the Interdisciplinary Journal of Problem-based Learning (IJPBL) and Special Issue Editor for Learning, Culture and Social Interaction (LCSI) on "Videos and Teacher Learning". She has served international associations such as the International Society for the Learning Sciences, Universitas21 (U21) Educational Innovation Cluster, QS Wharton Reimagine Education Awards and is immediate past Chair and current Communications Chair of the Problem-based and Project-based Learning SIG for the American Educational Research Association. Her co-edited book, Interactional Research in Problem-Based Learning was published as open-access with Purdue Press in 2023.

Dr. Michelle Sullivan is the Invention Education Learning and Curriculum Specialist for the Lemelson-MIT Program at the Massachusetts Institute of Technology. Michelle draws upon her transdisciplinary background to inform her work in educational research. Her recent publications and presentations include work on conversational interviewing grounded in interactional ethnographic principles, the networks that support and constrain invention education, working with previously collected records through an ethnographic lens, team-based qualitative analysis, and the benefits and costs of revealing hidden identities in the classroom. Michelle serves on the American College Counseling Association's Diversity, Equity, and Inclusion committee and the American Educational Research Association's Measurement and Research Methodology Division (D) Equity and Inclusion Committee Black Lives Working Group. She also serves as a reviewer for the American Educational Research Association's annual meeting.