

# AI-Enhanced Sociocultural Analysis of Keyboard Access in CSCL: Proxy, Gatekeeper, or Mediator of Intellectual Influence?

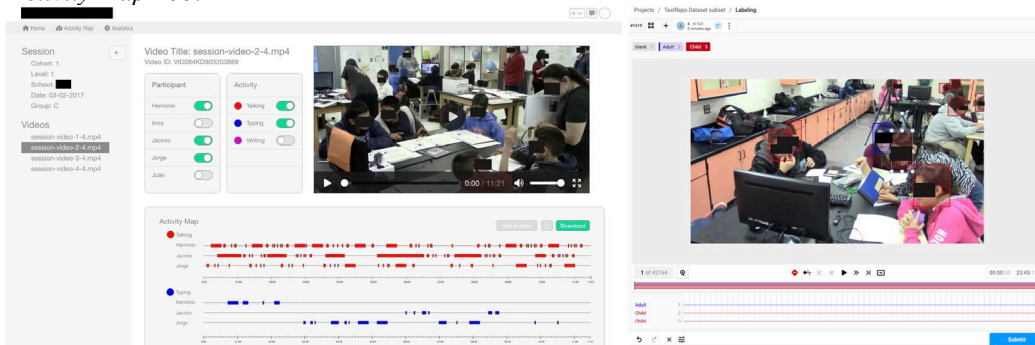
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**Abstract:** This study examines how access to a shared keyboard within collaborative groups reflects and/or mediates learning dynamics, as understood through patterns of social and intellectual authority. Incorporating an AI-powered video analysis approach to large-scale classroom video data with qualitative analysis, it explores group interactions among students in the integrated computer science and mathematics learning program. The study advances the understanding of power dynamics around shared tools, uncovering nuanced ways power relations are constructed, maintained, and challenged in collaborative learning.

## Introduction and background

Understanding the distribution of authority in collaborative learning environments reveals much about how learning processes unfold and evolve (Esmonde & Booker, 2017), while also highlighting the dynamic nature of power relations and their impact on learning outcomes. Engle et al. (2014) propose a framework for understanding undue influence in student discussions, synthesized by Langer-Osuna et al. (2020) into social and intellectual authority constructs. Social authority arises in interactions, while intellectual authority emerges during academic tasks, yet this critical dimension of research remains underexplored. Power dynamics are mediated by the availability of historically contingent artifacts or tools (Engeström, 2015; Esmonde & Booker, 2017). While artificial intelligence (AI) has been extensively explored for understanding learning and human behavior, its use to studying power dynamics among students in collaborative settings remains extremely limited. Additionally, there is little focus on how inequity emerges and authority is distributed in collaborative learning (Langer-Osuna et al., 2020). This study addresses these gaps by examining how access to tools relates to power dynamics and engagement, leveraging AI's strengths in analyzing large-scale data. This study uses the AI-based multimodal learning analytics tool, *Activity Map* (see Figure 1), which I co-created to longitudinally analyze group dynamics (Lee et al., under review), layering with qualitative methods for micro-interaction analysis.

**Figure 1**  
*Activity Map Tool*

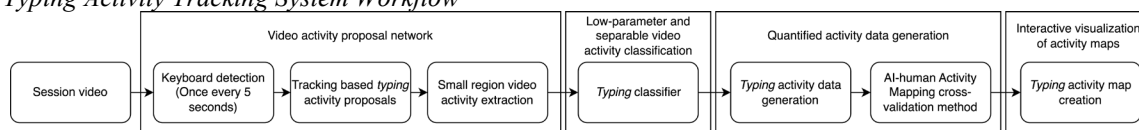


This study explores student groups participating in the AOLME program (NSF grants #1949230, 1613637; PIs: Drs. Celedón-Pattichis, Pattichis, LópezLeiva), focusing on how a shared keyboard—a deliberate setup to enhance computer-supported collaborative learning (CSCL)—serves as a pivotal resource for analyzing power dynamics within groups. Conceptualizing authority as a micro-construct of power, I examine how access to the keyboard reflects and/or mediates patterns in social and intellectual authority. Grounded in sociocultural learning perspectives, this study integrates the framework for modeling influence dynamics (Engle et al., 2014) and Cultural-Historical Activity Theory (Engeström, 2015) to examine interactions mediated by tools in social and cultural contexts. The activity system components—subject, object, tools, rules, community, and division of labor—frame the exploration of power dynamics. The proposed method of mapping group activities over time (see Methodology) can be seen as an exploration of the local histories of participation. Understanding these dynamics can help foster equitable participation and support the transformative potential of CSCL.

## Methodology

The dataset, comprising approximately 2,218 hours of multimedia data collected over three years in the AOLME program, was used to develop neural network models powering the Activity Map tool. The program, using a bilingual integrated mathematics and computer programming curriculum, is based on collaborative project-based activities and designed for two Title I middle schools with Level 2 curriculum covering object-oriented programming and robotics. This study analyzes 180 hours of videos from the summer 2018 cohort's Level 2 sessions (12 sessions) across six groups, involving a total of 39 students. This study employs a unique mixed-methods research design that innovatively combines quantitative AI-based Activity Mapping approach (Lee et al., under review), with qualitative manual coding and social interaction analysis (Jordan & Henderson, 1995). The method comprises four main phases. *First*, I generate activity maps for the videos using an AI tool, Activity Map, which detects and quantifies typing activities through four key stages (see Figure 2).

**Figure 2**  
*Typing Activity Tracking System Workflow*



*Second*, I synthesize activity maps by examining them over time to identify the patterns that exist within groups. Each activity map is classified into one of three categories—*Equitable/Dominant/Exclusive Access*—to reveal how group dynamics evolve across multiple sessions. *Third*, from each of the three categories, I randomly select two videos, totaling six sessions for detailed examination. Operationalizing social and intellectual authority (see Table 1 in Langer-Osuna et al., 2020), I manually code the context of keyboard usage in these selected sessions to identify the types of social and intellectual work occurring in relation to the keyboard. Based on a preliminary analysis of a single session, I hypothesize that the keyboard serves various functions related to power, such as a proxy, gatekeeper, or mediator of (intellectual) influence. *Finally*, I synthesize the data from all previous stages to examine how social and intellectual authority are distributed within groups.

## Scholarly significance

Examining tools in learning environments offers insights into how they mediate interaction, communication, and learning, as access to these often determines who holds authority and influence within a given context. In the case of one group, keyboard access emerged as a microcosm of broader social interactions and power negotiations in the collaborative group setting. There was a marked disparity in keyboard access, with certain individuals dominating this resource. Substantial contributions, such as coding or detailed analysis, were predominantly made by a subset of participants, reinforcing their socially negotiated degree of authority and influence within the group. This suggests that the keyboard's role extends beyond its physical utility to encompass significant sociotechnical implications in mediating access, controlling input, and shaping group interactions. This study will enhance our understanding of the power dynamics surrounding the use of the keyboard, shedding light on who can author and share ideas, and, consequently, whose voices are heard and valued. While the qualitative framework identifies authority configurations at the group level by focusing on discursive practices, activity maps reveal which individuals consistently occupy positions of authority or exclusion, capturing nonverbal interactions. By highlighting what they illuminate about each other, this work highlights the potential of AI to contribute to the analysis of power dynamics. Future research should focus on refining both the Activity Map tool and the analytical methods, as well as deeply exploring the affordances and limitations of such AI tools to build an analytical framework that can reliably inform discussions about equity and power.

## References

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