# Tools and Methods for '4E Analysis': New Lenses for Analyzing Interaction in CSCL

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**Abstract:** This symposium aims to expand the use of and perspectives on Interaction Analysis (IA) and related methods in CSCL, and to explore new ways of collecting, editing, visualizing and sharing research data, including video and location-based data. We bring the development and use of novel digital tools and IA methods to the foreground and invite participants to join us in reflecting on and designing the next phase of IA in CSCL, which in keeping with the theme of the conference is coined *4E Analysis*. During the session, we will share, compare and contrast four different digital tools and new approaches to studying collaborative learning that have been recently developed by CSCL researchers from across three different countries and five universities.

## Introduction

For the past 20 years, CSCL and Interaction Analysis (IA) have developed in tandem, with the classic Jordan and Henderson (1995) article introducing IA as a method and an approach to studying 'knowledge in use' (Hall & Stevens, 2015) published the same year as the first CSCL conference in 1995. One of the crucial links between CSCL and IA has been the use of video data to capture and describe interaction in ways that support studies of collaborative learning – from early studies of classrooms with shared computer screens to current interests in hybrid settings that are 'Embodied, Enactive, Extended and Embedded' (4E). For example, recent studies employing forms of IA from the International Journal of Computer-Supported Collaborative Learning have explored the role of talk and gesture for a pair of students collaborating around a shared touch screen (Davidsen & Ryberg, 2017), the role of teacher support for students performing lab work in science classrooms (Furberg, 2016), as well as the dynamic talk and movement patterns of families visiting a museum (Shapiro, Hall & Owens, 2017; Roberts & Lyons, 2017).

These studies show that the capability to collect, edit, visualize and share video data has expanded alongside other emergent data types and collection methods, including 360-degree video, wearable cameras, log data, location-aware technologies, as well as built and natural environments that are instrumented to link with mobile technologies. In CSCL research, such technological developments and new types of research data present a significant opportunity to extend the use of IA to explore embodied interaction, movement and learning processes from multiple perspectives, 'scaling' analytic attention in time, space (place), and social organization. Technological developments have opened a wider theoretical and analytical lens onto what constitutes situated and collaborative learning processes, allowing different types of questions to be posed. Some lenses are focused on ways of "representing and cataloguing choreographies of embodied interaction" for designing better support for mediated collaborative learning (Flood et al., 2015), while others are trained on "genres" of learning on the move to consider how people's movement through built and natural environments can be both the means and content of learning (Hall, Marin & Taylor, 2017; Bang & Marin, 2017). At the same time, we suggest that a common interest in groups, collaboration and social interaction uniquely situates CSCL research in relation to mainstream developments in data collection and tracking tools that are focused on networks of individual behaviors.

However, a critical challenge for the CSCL community is access to new computational tools to support such work, as well as the development of norms and practices around their use (Wise & Schwarz, 2017). Many CSCL researchers are unaware of new computational tools to collect, select, organize, manage, visualize, and analyze different types of data corpora in ways that support both qualitative and quantitative research. Moreover, while CSCL researchers are developing new computational tools and modifying IA methods to suit their particular needs, they often do so in an ad-hoc manner, rendering innovations in tools and methods secondary to the empirical studies they are intended to support. As a consequence, new tools and modified methods are often developed independently, and remain obscured or hidden from the general CSCL community.

 

This symposium aims to expand perspectives on IA in CSCL, and to explore some of the challenges in responding to new ways of collecting, editing, visualizing and sharing research data, including video and location-based data. We bring the development and use of novel digital tools and IA methods to the foreground and invite participants to join us in reflecting on and designing the next phase of interaction analysis in CSCL, which in keeping with the theme of the conference is coined *4E Analysis*. During the session, we will share, compare and contrast four different digital tools and approaches to studying collaborative learning interactions and learning on the move that have been recently developed by CSCL researchers. We wish, in part, to begin a conversation with our fellow researchers about possible new arrangements for capturing and using multi-perspectival, multi-scalar records of cooperative human activity. We will use these tools/approaches a) to show how innovative analytic tools and techniques are contributing to deeper understandings of 4E learning, b) to raise and identify new questions for CSCL research including how such tools allow us to expand and extend our units of analysis across temporal, spatial and social scales and c) to discuss shared methodological challenges.

## Overview of symposium format

The symposium will feature 4 presentations followed by an extensive facilitated discussion with opportunities for audience interaction and participation. Following presentations, we will structure a panel discussion where the audience can both engage with authors through questions while also having opportunities to use tools/methods shown in the presentations. We invite audience members to also raise their own issues and questions about new forms of interaction analysis. In light of the recent UN report on accelerating climate effects of CO2 production, we will incorporate a virtual component to this symposium for those wishing to participate while reducing air-travel. Additionally, Professor Rogers Hall will serve as a virtual discussant to the symposium by identifying common challenges and future goals from across the 4 projects.

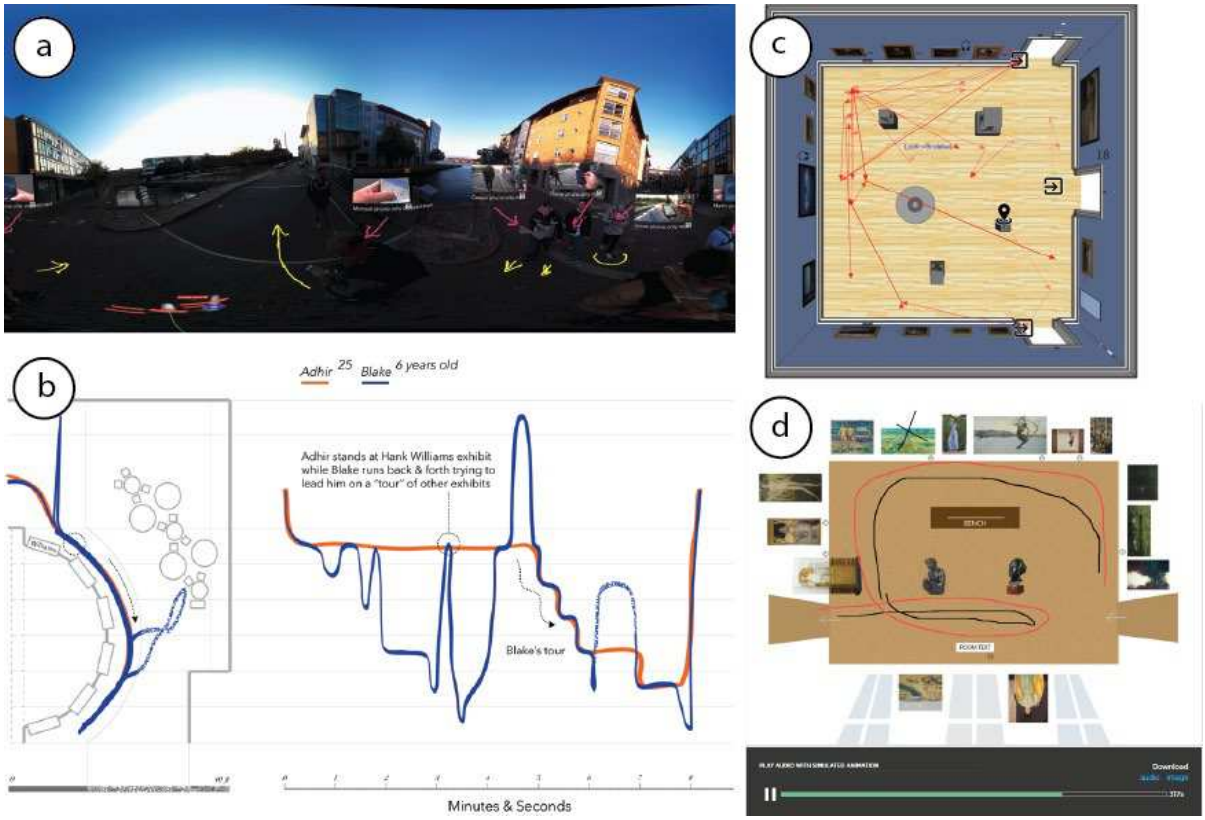


Figure 1. a) AVA360VR – Tool for analyzing and annotating 360 video footage in a VR environment, b) Interaction Geography Slicer (IGS) – Tool for linking movement and map data, to video and transcripts of social interaction, c) Visitracker - Software and tablet-based tool for observing and visualizing mediated interactions in museum spaces, d) Social Meaning Mapping (SMM)– Group interview method for 'real-time' recounting and drawing of embodied and embedded museum experience.

The above Figure 1 illustrates screenshots from the 4 different tools for studying collaborative learning interactions and learning on the move described more fully later in this proposal. The symposium will thus not merely present these 4 tools, but will emphasize looking across the approaches to support broader methodological comparison and reflection. For example, though each of the included tools direct analytic attention to participant movement, this feature of interaction is visible in different ways including 360 video footage as well as a variety of map visualizations that emphasize temporal relationships, mediated action, and participant narratives.

## International panel and areas of expertise

### Norway

**Rolf Steier** is an Associate Professor in the Department of Education at the University of Oslo. His research focuses on collaborative learning processes in a variety of contexts and disciplines including museums, classrooms, and professional design settings, with specialized interest in the relationship between face-to-face and embodied collaboration, and mediating technologies.

**Dimitra Christidou** is a senior researcher in the Department of Computer Science at the Norwegian University of Science and Technology where she is working for the H2020 COMnPLAY SCIENCE project.. Her research focuses on museum learning, visitor studies, multimodality, and embodied interaction. Dimitra holds a PhD in Museum Studies from University College London (UCL) and has working experience as a researcher in the museum sector in Sweden and Greece.

**Palmyre Pierroux** is Professor at the Department of Education, University of Oslo. Pierroux's research is focused on technology-enhanced learning in informal settings. She specializes in design-based research methods and leading projects based on research-practice partnerships with museums.

### Denmark

**Jacob Davidsen** is an Associate Professor in the Department of Communication and Psychology at Aalborg University. His research focuses on collaborative activities in different contexts and disciplines including architecture and design education and Problem Based Learning environments. He is specialized in embodied interaction analysis with a particular focus on collaborative activities.

### United States

**Ben Rydal Shapiro** is a Postdoctoral Fellow in the School of Interactive Computing at Georgia Institute of Technology. His research and design integrates approaches from the learning and social sciences, information visualization and architecture to study how people engage and learn in relation to the physical environment and to develop new types of learning environments and experiences.

**Rogers Hall** is a Professor in the Department of Teaching and Learning, Vanderbilt University. His research concerns learning and teaching in STEM conceptual practices, comparative studies of embodied action in these practices, and the organization and development of representational practices more generally.

## Paper 1: AVA360VR – Annotating, visualising and analysing CSCL processes in VR

Jacob Davidsen

With the recent advent of consumer 360-degree cameras and spatial microphones new opportunities for studying human interaction and collaborative learning processes arise. The 360-degree cameras offer a more holistic and environmentally sensitive record of collaborative learning interactions compare to traditional 2D flat recordings. With a 360-degree recording it is possible to navigate the field of view after the capture of the event, which can afford a better understanding of interaction in context and a more explorative attitude towards the analysis. Nevertheless, the existing tools supporting the process of transcribing and analysing embodied learning interactions (e.g. ELAN, Transana, etc) are not suited or build for working with 360-degree recordings. As a consequence and as part of our exploration of 360-degree cameras and spatial microphones over the last years, we have suggested a 'scenographic turn' in the analysis of human interaction (McIlvenny, 2018; Mcilvenny & Davidsen, 2017). While 360-degree video footage fosters new ways of annotating, visualising, analysing and

disseminating interaction analytic work, it is also clear that new tools are required for utilizing this technology for interaction analytical purposes.

As a response to the technological development in video technology and as part of our work under the banner of Big Video (www.bigvideo.aau.dk), we have developed a tool for working with 360 degree recordings (McIlvenny, 2018; Mcilvenny & Davidsen, 2017). AVA360VR (Annotate Visualise Analyse 360° video in VR) is a Unity based software allowing researchers to work with 360 video in a more 'natural' interface in virtual reality. Basically, AVA360VR is offering a more tangible and immersive engagement with current (and future) spatial video and audio recordings. As described by Mcilvenny (2018) some of the basic functions are "(a) scanning the field of view in 360°, (b) using the controllers, (c) using the timeline, (d) annotating, (e) inserting simultaneous video streams, (f) re-caming, and (g) deploying interactive transcript objects. Many of these remediate familiar operations – such as pointing, grabbing, drawing and watching two monitors – but with added functionality because of their virtualization".

With AVA360VR we are seeking to take advantage of the developments in video technologies for enhancing the analysis of embodied interaction in CSCL environments. As noted by Flood, Neff and Abrahamson (2015) there is a need for CSCL to develop ways of "representing and cataloguing choreographies of embodied interaction" (2015, p. 96) in order to better design for collaborative embodied interaction in CSCL environments. However, as discussed by Davidsen and Ryberg (2017) the transformation of embodied interaction into transcripts (traditional or multimodal) is by no means doing justice to the simultaneous, creative and complex choreographies of intercorporeal interaction playing out between the collaborators in CSCL environments. With AVA360VR new opportunities for 'cataloguing choreographies of embodied interaction' is possible, without reducing it to traditional transcript text. It becomes possible to inhabit the data. At the symposium, AVA360VR will be demonstrated with data from architectural education, where a group of 1st year students are collaboratively preparing for a critique session.

## Paper 2: Studying collaborative interaction across museum & city scales with the Interaction Geography Slicer (IGS)

Ben Rydal Shapiro and Rogers Hall

Describing and representing collaborative interaction as people move across different physical environments is a significant challenge for many communities. For the computer-supported collaborative learning (CSCL) and learning sciences (LS) communities, this challenge is further complicated by the need to interpret collaborative interaction as people move across physical environments from a learning perspective. This paper illustrates a dynamic visualization tool we have developed and call the Interaction Geography Slicer (IGS). The IGS dynamically visualizes data including audio/video data and location-based data about people's movement, conversation, and social media activity over space and time. Likewise, this paper uses the IGS to study collaborative interaction from a learning perspective across two different scales. The first scale is visitors' collaborative interaction across museum gallery spaces. The second scale is students' collaborative interaction as they create and follow historical walking scale tours of their local urban environment. To interpret collaborative interaction from a learning perspective at both scales, this paper draws from a growing body of research that views walking as a form of public discourse (see Marin, 2013; Zimmerman et al., 2016) where learning often arises either from moments where people "make places" to engage with entities or phenomena of interest (Lave, 1984; Ma & Munter, 2014; Christidou, 2018; Steier, 2014) or alternatively, designed pedagogical sequences where move through built and natural environments to learn (Taylor & Hall, 2013).

Findings from this paper show how the IGS provides new visualization and visual analytic techniques that advance different approaches to studying collaborative interaction from a learning perspective. In particular, at a museum scale, findings show how the IGS supports the characterization of interaction geography, an approach to describing, representing, and interpreting collaborative interaction as people move across physical environments (Shapiro, Hall & Owens, 2017; Shapiro & Hall, 2018). This approach encompasses units of analysis such as "engagement contours" and supports asking and answering new questions such as how young children use their families as resources for learning through their seemingly erratic movement patterns. At a city scale, findings show how the IGS supports a broader characterization of people's interaction as Time Geography (Hagerstrand, 1970) in ways that highlight differences in how people learn from creating and following historical, walking scale tours. Moreover, findings show how the IGS supports traditional and new forms of interaction analysis on the move (Jordan & Henderson, 1995; Hall & Stevens, 2015) at both museum and city scales. Altogether, this work raises important questions for the CSCL and LS communities as to the strengths and weaknesses of different analytical approaches to studying collaborative interaction and ways of integrating different analytical approaches to study collaborative interaction in new ways.

## Paper 3: Mapping mediated interaction in museums: Visitracker tool for ethnographic observations of visitors

Rolf Steier and Palmyre Pierroux

Studies of museums as informal learning environments have identified the significance of talk, movement and physical orientation in mediating visitors' collaborative meaning making (Steier, Pierroux, & Krange, 2015). To capture visitors' interactions in these rich semiotic settings, learning researchers have employed methods and approaches from interaction analysis for the past twenty years (Leinhardt & Crowley, 1998; Rowe, 2003), furthering the development of innovative techniques for collecting and analyzing video data (vom Lehn & Heath, 2007). Findings from these studies have been particularly valuable for CSCL research on 'informal learning,' e.g., technology-enhanced learning on museum field trips (Bakken & Pierroux, 2015), and the design of texts, technologies and other contextual resources to adapt to personal knowledge and interests in different disciplines (Davis et al., 2015; Pierroux & Ludvigsen, 2013). At the other end of the methodological spectrum, there is an even longer history of *visitor studies,* with consultants continually refining methods and tools for 'T&T' studies (tracking & time) of visitors' movements. These studies are based on observations or other (digital) recordings of where individual visitors walk, where they stop, and how long they stay there (dwell time). These generally large datasets are considered valuable for practice, providing demographic and attendance information, mapping 'paths' and popular attractions, and indicating use of services. In this paper, we present a tool collaboratively developed over a ten-year period that combines insights and interests of *both research and practice*. Visitracker was inspired by paper-based protocols and developed into a tablet-based digital tool iteratively over several years with museum partners in Norway (Pierroux & Steier, 2016).

Visitracker is a portal and tablet application that was developed in a research project to record, log and visualize (anonymized) observations of visitor groups and their interactions, movements and use of resources in the physical spaces of the museum in real time. The aggregate data are recorded and visualized using maps and other graphical representations. Maps are a familiar representational tool in museum practice, used by exhibit curators and architects in the design of exhibitions, to make decisions about spatial arrangements and the sequencing of works on display. Maps are also used in the field of visitor studies to record visitors' movements and paths through a museum or gallery floor (Bitgood 1988). As mentioned, data in these studies are often used to address questions of traffic flow and circulation designs or spatial aspects that may relate to an exhibit's popularity. However, despite the potential to represent relationships between physical context and social learning interactions, maps are typically absent from sociocultural research data. Some research, such as classroom learning studies by Roth et al. (1999), have used maps to represent aspects of sociocultural research data. However, the use of maps as data is largely underutilized and unexamined from a perspective of mediated action. Maps may, by complementing other forms of data, visually highlight aspects of actions and meaning making not visible in the words of notes and transcripts.

Visitracker provides a visual overview of a physical context in which groups of visitors move and interact, and allows the researcher to document the location of the participants, their use of particular resources, and the activity. In contrast to visitor studies methods that note the time spent by a visitor standing in front of a display as an indicator of attention or learning, a researcher using Visitracker documents whether the visitor is looking at the exhibit, talking with a friend, pointing across the room, reading a text, listening to an audio guide, conversing with a friend, etc. The unit of analysis is expanded to include not just the physical location and time, but also the social aspects of group interaction and mediational aspects of resource use. By visualizing the pathways taken by groups of museum visitors and the types and locations of their interactions, we can pose new questions at a larger scale about which resources are made relevant, how multiple social interactions relate to each other in a given space, and how a sequence of actions may relate to different physical and social contexts. If a shared goal of visitor studies and museum learning research is to understand visitor experiences and meaning making processes, then new means of collecting, visualizing and sharing data using Visitracker contributes to advancing this aim.

## Paper 4: Social Meaning Mapping: a digital tool for visitors to map their museum experience

Dimitra Christidou

Social Meaning Mapping (SMM) is a qualitative tool embedded in the Visitracker app, designed as a post-visit research tool used during a researcher-led session for documenting/recording visitors' experience in one gallery room. For SMM, visitors are prompted to recount and recreate their movement through the room by drawing on

the digital surface of the tablet using resources from a toolbox available while also sharing their thoughts on their experience with the researcher and each other. SMM addresses a methodological challenge of incorporating visitors' own narrative understandings of their movements and meaning making processes into data collected by researchers through in-gallery observations (i.e. time and tracking studies).

The app allows visitors to depict their path either on a digital floor plan of the room they visited, or recreate their path on an empty canvas. As such, the dataset created through SMM is comprised of (i) digital trails that visitors draw by using the tablet, and (ii) audio-recordings of visitors' narrations regarding their experience in this room. SMM data can be complemented by the dataset collected through the other two methods for data collection available on Visitracker (i.e. survey and in-gallery observations). Visitracker portal makes it possible to display the drawing process on the tablet in synchronization with the audio recorded conversations (Figure 1d).

The design of SMM has been informed by relevant methods used in visitor studies approached now through a sociocultural lens (Wertsch, 1991), and the theory of navigational learning (Peterson and Levene, 2003). Particularly, SMM has been inspired by the Personal Meaning Mapping (PMM) tool, a well-established tool in visitor studies (Falk, Moussouri & Coulson, 1998; Adams, Falk & Dierking, 2003), and other similar approaches using visitor recall maps, or self-reported pathway maps (Rainbolt, Benfield, & Loomis, 2012) and visitors' drawings (Diamantopoulou, Insulander, & Lindstrand, 2012; Insulander & Selander, 2009).

In PMM approaches, a single visitor is usually invited to respond to a keyword written at the center of a blank sheet of paper and write words and phrases that are related to this keyword before and after the museum visit. Shifting the attention away from foregrounding individual and linguistic prompts, the SMM approach is designed to be used by groups of two to four visitors only post visit, enabling them to recollect, negotiate and visually co-construct their route, making the drawing task a prompt for a discussion recorded in the app. As a result, SMM marks a shift away from the usual quantitative approaches to data collected via PMM, which measure the extent of visitors' knowledge and attitudes based on the number and range of concepts/words written. SMM extends such 'reflective tracking' methodologies (Falk et al., 2007) by embracing a sociocultural perspective (Wertsch, 1991) which considers meaning making as mediated in and through social interaction and the use of cultural artefacts. Sociocultural perspectives place visitors' own experiences, and therefore their spoken and written self-reports, at the core of investigating their meaning making. By making available the possibility of drawing on a floorplan and using it as a prompt for visitors to talk about their embodied experience in the gallery room, SMM transforms static maps such as the floorplan image into 'dialectical artefacts' (Stahl, Ludvigsen, Law, & Cress, 2014, p. 239) produced by visitors in collaboration with each other and in interaction with the affordances of the SMM tool (i.e. tablet's screen, toolbox etc.). In this light, visitors' map making is seen as an 'act of representation' – that is, 'the act of highlighting aspects of our experience and communicating them to others and ourselves' (Enyedy, 2005, p. 427).

Data collected through SMM allows us to synthesize various aspects of visitor experience collected through different methods (i.e. observations, survey) and attend to the individual and social aspects of the visitors' experience (Grack Nelson & Cohn, 2015) as recounted and re-negotiated by visitors themselves. They further offer opportunities for visitors in groups to elaborate on each other's trail and exchange ideas, comments, and interpretations.

Trails are paths constructed by museum visitors, linking a series of encounters with individual artefacts, resources and other visitors, detailed through their own descriptions and interpretations recorded using Visitracker. Visitors are invited to 'see' and 'write themselves' on the floorplan by noting their movement while talking about their experience using the drawing tools available. As such, trails provide one way of linking artefacts and interpretation in a narrative through a process consisting of 'enacting' or creating trails, then editing, discussing and sharing them with other visitors in their group and the researcher. What is shared is not merely a list of resources, objects or places, but a path, which places these objects in a spatial, temporal, and/or categorical context. Additionally, trails are a tool for facilitating visitors' discussions about particular exhibits by indicating their position in the gallery and without needing to recall the names of the artists, or the titles of the paintings using art-related language.

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