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Community technology mapping: inscribing places when "everything is on the move"

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Abstract Interactive, digital mapping technology is providing new pedagogical possibilities for children and their families, as well as new methodological opportunities for education researchers. Our paper reports on an example of this novel terrain we call "Community Technology Mapping" (CTM). CTM was a designed task that was part of a larger ethnographic study of children and families' digital media and technology practices in and around their homes. CTM incorporated interactive digital mapping technology with a structured interview protocol as a pedagogical context for young people and a methodological tool for researchers. As a pedagogical context for computer-supported collaborative learning, CTM supported young people to see and reflect on their everyday technological practices as temporally and spatially organized across scales of human interaction. As a methodological tool, CTM allowed researchers to see families' place-based and on-the-move activities that were outside the more naturalistic observations of home-based technology use. Our analysis of CTM draws upon video recordings and screen captures of young people's reflections on and live mappings of places they typically used technology and engaged with media. We found that children developed strategies with the mapping technology to make places visible, make them coherent, and make them mobile. These strategies produced a "cascade of inscriptions" within the CTM task for mapping new mobilities of digital, daily life. We argue that interactive digital mapping technologies not only support researchers to ask new questions about the spatiotemporal aspects of learning phenomena, but also contribute to a new genre of place-based, digital literacies- locative literacy- for learners to navigate.

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Introduction

Understanding how people use technology to collaboratively achieve new ways of seeing and learning about the world is a core issue for CSCL. When the technologies change, so changes the nature of collaboration and how we study "the type of learning that takes place in collaborative groups and the design of collaborative learning processes" (Cress et al. 2015, p. 109). This article focuses on a novel pedagogical and research approach for computer-supported collaborative learning we call Community Technology Mapping (CTM). In what follows, we describe the design of this approach that utilized interactive digital mapping and geospatial technologies to support a new form of digital literacy.

Young people's learning over time and across settings has always been mediated by technologies, be they older or newer tools. This "irreducible tension" between learner and meditational means has been an interest of sociocultural research for many years (e.g., Wertsch 1991; Vygotsky 1978; Cole 2006), with significant implications for computer-supported collaborative learning (Roschelle and Teasley 1995). But in just the past decade, the nature of these technologies has changed drastically, and the rate of change increased exponentially (Friedman 2016). Today, ubiquitous mobile media (e.g., Google Maps™, Twitter™, YouTube™, Pokémon Go™ in combination with unlimited data plans on smartphones) amplify the many ways and number of locations in which learning opportunities arise. Each seized learning opportunity might now include physically co-present participants or geographically and temporally distant collaborators (e.g., Farman 2010). Understanding how technological change and learning intersect- and how such junctures create opportunities for new ways of experiencing and knowing the world- requires developing methods for observing these mobilities in everyday activity (Leander et al. 2010) and pedagogical tools that support new forms of digital and spatial literacies (Taylor 2017).

Digital mapping software and geospatial applications are potential assets for researchers to examine emergent, distributed, and mobile aspects of learning (Taylor et al. 2017a). Applications like Google Earth™, Google Maps™, and Social Explorer™ support the geovisualization of patterns (Elwood 2010) that may be related to family travel, leisure activities, and available community assets (e.g., libraries, community centers, schools). But we still need a more complete understanding of how these widely accessible tools not only present new means of investigation for us, but also create a new genre of digital literacy for *learners* to navigate (e.g., diSessa 1997).

Little is known about interactive digital mapping technology as a methodological tool in education research *or* as a pedagogical tool in design-based studies with children (Gordon et al. 2016). How, for instance, might this technology open up new digital literacies, allowing children to, among other things, see their own routines as spatiotemporally organized phenomena (Ellegård and Hägerstrand, 1977) and think across scales of human activity (International Society for Technology in Education (ISTE) 2016; NGSS Lead States 2013; Taylor and Hall 2013; Taylor 2017)? These literacies bear significance across an array of disciplines that consider the human relationship to our planet (e.g., ecology, urban planning, geography, climate science). In this context, education researchers are developing new CSCL environments (e.g. Shapiro et al. 2017) and pedagogical arrangements (Higgins et al. 2011) to help specify relationships between children's engagement with emerging digital technology and diverse places in which their learning occurs.

The objectives of this paper are twofold. The first objective is to describe a methodological innovation that uses interactive digital mapping technology. The second objective is to analyze this method as a pedagogical tool for young participants (and their parents) to learn a new genre of digital literacy. In this way, the current analysis addresses a central premise of CSCL, which Stahl et al. (2014) recently articulated in their definition of the field. That is,

> CSCL research is both a theoretical enterprise, concerned with how groups make meaning, and a design endeavor, concerned with how to design artifacts of collaboration media, representational guidance, group interaction and pedagogical approaches to promote collaborative learning (p. 239).

Regarding our first objective, we want to introduce and advocate for a new method of exploring young people's understandings of and relationships to places they regularly go during their "daily media rounds" (Taylor et al. 2017b), or their regular routines that increasingly involve digital media. This method, which we call Community Technology Mapping (CTM), involved a task that children completed at the end of a larger ethnographic study of their mobile technology use. In this task, children were asked to create a map in Google Earth™ by identifying and drawing places and pathways where they regularly spent time using (and not using) technology. This method, we argue, helped researchers see important learning and teaching activities that happened outside of more naturalistic observations of children using technology around their homes. In this way, CTM allowed researchers to create a more holistic picture of typical weekly activities and spatiotemporal patterns in families' learning lives (Erstad 2012).

The second objective of this paper is to analyze young people's participation in CTM as an example of a new form of digital literacy we call "locative literacies" (Taylor 2017), which involve the use of new, location aware media to support learning about place and space. This objective brings CTM into line with a rich body of work in CSCL concerned with the development and empirical study of computer-supported pedagogical tools for knowledge sharing. Extending extant studies of collaborative activity supported by computer screens (Stevens 2000), multi-touch tables (Higgins et al. 2011), mobile phones (Roschelle and Pea 2002; Ryokai and Agogino 2013), digital video (Zahn et al. 2012), VR (Yoon et al. 2012), and museum exhibits (Shapiro et al. 2017), we are contributing a novel pedagogical approach for studying learning during *collaborative digital mapping*. Through CTM, young people learned how to see their typical daily lives as spatiotemporal phenomena that are organized by a confluence of factors, including time constraints, the built environment, and interests shared between family members. Participants also created new renderings of places and pathways on the map that represented their connections to places of import.

Our two objectives guide the following research questions:

- *What were researchers able to see about children's daily media rounds from the mapping task?*
- *What sorts of strategies did young people use to make their everyday places and pathways known (to themselves and others) within the mapping task?*
- *How did CTM support young people to consider the spatiotemporal organization of daily life?*

To answer these research questions, we analyze the processes of *inscription* (Latour 1986, 1987) that organized children's activities in and out of the CTM task. We will describe how children's participation in CTM followed a typical set of processes that allowed them to inscribe places they routinely went during a week (e.g., school, the YMCA). We call this typical set of processes *inscribing places*, which occurred as children made places *visible*, made places *coherent*, and made places *mobile*. Places that children inscribed included grandparents' houses, schools, grocery stores, community centers, friends' houses, and their own homes. Our analysis shows how these three processes involved children coordinating the resources available to them in their social-material surroundings (Goodwin 2013), including other family members, routine qualities of daily life, and familiar aspects of their neighborhoods. We further argue that by making it possible for researchers to see children's daily activities and weekly itineraries, this CSCL pedagogical approach disclosed how children's relationships to places are being re-mediated (Cole and Griffin 1983) by new digital technologies.

In what follows, we outline the conceptual terrain in which this study is situated, highlighting several key concepts that framed our analysis. Next, we describe the research design of the overarching study of which the CTM task was only one component, and how we analyzed children's participation in the task. Then, we present our findings in three sections, elaborating how, in inscribing places, children made places visible, made them coherent, and made them mobile. Finally, we discuss how these findings add to methodological and pedagogical understandings of learners' technologically mediated and mobile activities. We argue that by making it possible for researchers to see children's daily and weekly activities, the task served as a unique site for disclosing sociotechnical arrangements (Star 1999) that underlie children's relationships to place and space. We draw on these findings to suggest how CTM presents a methodological and pedagogical context for studying a new genre of digital literacy- locative literacies- that involves location-based and digital mapping technologies.

Framework

(Digital) maps as inscriptions

As Enyedy (2005) wrote, "Like any symbol system, whether it is a programming language or mathematical notation system, maps are powerful ways of seeing and understanding the world around us" (p. 428). Across much of human history, maps have been paradigmatic "inscription devices" (Latour 1986), meaning any tool or technique that works to represent and reproduce knowledge of the world. Through iterations of inscriptions (i.e., from scalable drawings *in situ* to automated reproductions of paper-based maps for mass production), early explorers drew up maps of the entire world. Latour (1987, 1991) contended that these maps thereby drew together all the human and nonhuman actors enrolled to produce them.

Paradoxically, this labor that made the world visible and transportable, effectively rendered *in*visible all the social and material work that went into translating heterogeneous perceptions of place into Cartesian space (e.g., Star 1999). Latour called the map an "immutable mobile," meaning, it maintains its representational power (immutability) precisely because it has been mobilized through this chain of production (and erasure). The outcome of such sociotechnical work is a discernible, coherent, transportable map (Latour 1987). Such a way of thinking about maps as inscriptions has, in turn, mobilized a whole body of literature concerned with the sociotechnical construction of cartographic knowledge (e.g. Bingham and Thrift 2000; Vertesi 2008).

Contemporary cartography has been (and continues to be) reconfigured through interactive digital media (e.g., Phillips 2013) where the on-going production of space takes place at the computer interface. Digital maps are an example of what Stahl et al. (2014) refer to as dialectical artifacts (p. 239), because they are produced by the very interactions which they mediate. Maps are also increasingly dynamic, multi-perspectival, crowd-sourced, publicly audited, and open-source (Farman 2010). This re-figuring of an old and established sociotechnical system–and in light of new mobilities largely rendered by the digital—requires a reconsideration of the notion of immutable mobiles (Lammes 2016; November et al. 2010).

The mobile aspects of maps can now be thought about in a number of ways. Two of these aspects are most relevant to our study. First, digital maps disrupt a fixed representational grid intelligible in two dimensions and orient users to a dynamic spatio-temporal dimension that moves around as you interact with it. Places and points of interest are made visible and mobile through on-screen navigation to and through them. Whereas paper-based maps restricted representations to what would fit onto folded paper, today emergent features of the landscape, 3D buildings, and live traffic events materialize on the edge of the digital screen. Second, a user's physical mobility is altered through the new mapping interfaces (Jenson et al. 2015; Lammes 2016); while navigating with a digital map application, one's geo-referenced position moves on the surface of the map, so the user can adjust her pathway accordingly, in real time. In virtual space, a person can move themselves (sometimes with the aid of an on-screen icon or avatar such as Google Earth's Pegman, or the ubiquitous blue dot in Google Maps) through mapped spaces, visiting places they have never been before in person or would like to re-visit.

November et al. (2010) posit that because of users' interactions at the digital map interface (i.e. the re-mediation of space through technology), many of the invisible actors and processes lost in translations of place to paper are re-materialized. Digital maps have the ability to render visible and mobile all the inscriptions of these heterogeneous actors, reassembling them in the event of a user navigating. As November and colleagues put it, "*everything is on the move*" [italics in original] (p. 596) once mapping is conceived of in this new way. They continue,

> Today it is impossible to ignore that, whenever a printed map is available, there exist, upstream as well as downstream, a long and costly chain of production that requires people, skills, energy, software, and institutions and on which the constantly changing quality of the data always depends (p. 584).

Interactive digital mapping opens up the possibility for learners to see and analyze parts of this chain of inscriptions.

Methods for mapping learning and mobile media

Research is just beginning on how young people negotiate inscriptions (Taylor 2017) through interactive digital mapping (e.g. Gordon et al. 2016). Learning on-the-move (Taylor and Hall 2013) requires new methods for mapping new mobilities (Leander et al. 2010) that specify the spatiotemporal dimensions of sociotechnical systems in which everyday learning is embedded. Such methods attend to how mobility through space- of people and their technologically mediated activities- can be observed and documented (Taylor et al. 2017a, b). An early innovation supporting this work was the advent of video recording technology and its affordances for understanding movement of people and their tools in and across activity settings (e.g., Stevens and Hall 1998). More recently, tools like wearable cameras (i.e.

Taylor and Hall 2013; Umphress and Sherin 2015) and augmented reality (Ryokai and Agogino 2013) are being used in learning research to capture and facilitate participants' dynamic interactions.

A secondary challenge for researchers studying learning on-the-move has been to develop a means of documenting place-based dynamics or "targeting the spatial aspect of learning" in the data record (Leander et al. 2010, p. 356). In other words, digital maps now serve as vital tools for developing methods for literally mapping the new mobilities of learners. Mobile and geolocative technologies (i.e., GPS and GIS) have been invaluable in this regard, and a number of recent studies of learning and mobility have utilized the geolocative capability of mobile devices (Gordon et al. 2016; Hall et al. 2015; Taylor 2017). Geolocative technologies have been used to augment place-based learning (Kimiko and Agogino 2013), to design novel learning activities for bodies on-the-move (Taylor and Hall 2013; Ma 2016), and to reconfigure how we represent spatial data (Shapiro et al. 2015).

Long interested in how young people construct spatial representations of their everyday experiences (Hart 1977), the field of children's geographies has catalyzed these new methods for understanding learning in and about places. More recently, novel empirical tools have made young people's own understandings of place-making (e.g., Taylor & Phillips, 2017) visible in Q7 research (e.g. Gordon et al. 2016; Santo et al. 2010). CTM follows in this innovative methodological tradition (e.g. Hall et al. 2015) and also leverages a popular media platform (i.e., Google Earth) and GIS technology that geographers and educational scholars are now utilizing to understand learning phenomena (Patterson 2007). Google Earth, the online digital mapping application we used in the CTM task, has been used in a small number of studies of learning, for example, to reconstruct historical narratives of places (Gordon et al. 2016). The present analysis of CTM builds on this scholarship by presenting a design for an interactive digital mapping task that collaboratively develops learners' locative literacies building upon their cartographic, digital inscriptions of their weekly itineraries.

Locative literacies

In the two decades since multiliteracies became an educational focus (Cazden et al. 1996), the role of digital technology in young people's lives has changed dramatically. Whereas more formal competencies like computing and coding (e.g. diSessa 1997) still garner researchers' attention, understanding how young people learn and, to some degree, live their lives online is of central concern in today's digital literacies research (Ito et al. 2013). However, persistent "digital native" discourse perpetuates a view that youth in a networked era come to their varied technological practices with already well (in)formed ideas about tools and technical know-how (Jenkins et al. 2017). It is simply not the case that young people approach new media and Q8 technology fully literate. Rather, developing fluency with technology requires support (Barron et al. 2009) and takes place through collaborative participation in cultural practices (Cress et al. 2015; Roschelle and Teasley 1995) that are constantly being re-mediated by emerging technologies (e.g., Cole 2006). Using dynamic and interactive digital maps is an example of how educators and caregivers cannot assume children are fluent users because they have seen a paper map or watched someone use a digital map application.

Maps have a history as pedagogical tools in educational research (e.g. Enyedy 2005; Enyedy and Mukhopadhyay 2007) however interactive digital maps have not received substantial attention in the literature on multiliteracies or computer-supported collaborative learning.

Like all literacies, digital literacy involves uptake of reading and writing practices (Gee 2003), dialectical processes of deciphering (reading) and inscribing (writing) one's world (Freire and Macedo 1998). These processes are inherently ideological, and learning in digital contexts inherits all the traditional, analog struggles over agency, authoring or legitimizing knowledge, and accessing opportunities to learn (Ito et al. 2010). Locative literacies then reorient traditional literacies around two axes: new media and emerging social spaces for learning. Digital tools amplify the temporality and spatiality of reading and writing practices- and re-mediate place-based ways of knowing- by opening up new opportunities for learning across (and about) contexts (Leander et al. 2010).

Learning is not just situated *in* contexts, but organized by contexts (Lave and Wenger 1991; Ma and Munter 2014). What has been called the "spatial turn" (Kingston 2010) in the social sciences invites new analyses of digital literacies that foreground the heterogeneous space-times (Leander et al. 2010) and the (often contentious) processes of place-making (Taylor & Phillips, 2017). Mapping software and applications like Google Earth present potential pedagogical opportunities for developing new forms of digital literacy because they key into the already spatially-inflected and mobile aspects of learning. We concur with cultural geographers Elwood and Leszczynski (2012) who have written that,

> The ascendance of location as a primary way of engaging the web and the increasing ubiquity of digital media with a spatial component suggests a comparative accessibility and ease of use to these technologies by non-experts in a wider range of everyday practices… [and] may be part of a transformation in the forms of action that individuals and social groups understand as constituting activism or engagement (p. 556).

It is this notion of locative literacies- as transforming the forms of actions that constitute engagement in everyday practices- that CTM was designed to support and make visible.

Design and methods

Community Technology Mapping is a method that emerged from a larger ethnography called Learning across Networked and Emergent Spaces (LANES), designed to investigate the role of mobile media and technology in reorganizing families' everyday routines in and around their homes (Taylor et al. 2017a, b). The LANES project was itself part of an even broader multi-sited, multi-year, multi-method effort to understand families' changing technology and media engagement, the Families and Media project (Gee et al. 2017).

We consider this larger ethnography and its methods an example of *digital ethnography*, a new approach or collection of approaches that account for how social processes emerge in the digital age and with digital tools and practices (Pink et al. 2016). While some digital ethnographies focus on activities that take place specifically in virtual spaces (e.g. boyd 2014), other forms examine broader contexts in which digital media and technology are implicated, which may involve studying the media engagement of physically co-present participants and/or their online activities. It is in this latter, broader sense that CTM and other methods were employed in this study.

The purpose of our digital ethnography was less about focusing explicitly on the social significance of a single device or media form (i.e. tablet computers, the latest video game, or Google Earth, for that matter) and more about orienting the ethnographic lens towards what is technological about how research participants are going about the activities under study (Pink et al. 2016). The larger study included video-recorded participant observation, interviews, and experience sampling, in addition to the CTM task. CTM incorporated interactive digital mapping technology with a structured interview protocol as a CSCL pedagogical context for young people and methodological tool for researchers. In what follows we describe the task structure, the participants and setting, and our analytic approach.

The CTM task protocol

The CTM task took place during the final observational visit with each family in the study. CTM was designed to address two explicit objectives: (1) to make visible how children used mobile media during their daily rounds (Erickson 2004) at times not observed during fieldwork and (2) to facilitate children's reflections on the relationships between physical environment and digital technology use. The typical activity structure of the task can be broken down into five main steps (see Appendix for CTM protocol). First, a researcher accessed Google Earth (GE) on her laptop and established a participant's comfort level with using GE to map places they frequently go, providing assistance and instruction when necessary. Most participants had some prior working knowledge of the application.

Next, the researcher asked the participants to map places they regularly went where they might use technology. During this phase, participants identified and located these places, dropped a marker on the location, labeled the location, and repeated these sub-steps for each location they chose to map. After participants had found and labeled these places, the researcher asked them to draw the pathways they typically traveled between them; most participants were able to trace pathways between at least a few places. Then, the researcher asked participants to identify and label technology "hotspots," or places where they felt most engaged with technology, usually by changing the location's marker color. Finally, in the post-task phase, the researcher debriefed the CTM task with participants and sometimes with a parent in a follow-up interview (see Appendix for final interview protocol). The task typically lasted one hour per participant.

The task settings

CTM was typically performed in children's homes and on the researchers' laptops, most often at the kitchen or dining table, though sometimes in the living room. The task was collaborative in that it always involved at least one other person- such as a parent, a sibling, or simply the researcher- as well as the technology being used for digital mapping. While we generally reserve discussion of these interactions and the attending place-making processes for empirical analysis, it is worth describing the home settings and media ecologies in which CTM activities were set. This description gives a sense of the material and personal configurations that will become important later on for establishing how inscribing places occurred.

The kitchen or dining table was the most common spot in the house for conducting the CTM activity. The relatively large table surface allowed young people and their collaborators to sit side-by-side and operate the computer while co-viewing the screen (Takeuchi and Stevens 2011). It also permitted the researcher to position herself nearby, usually at an adjacent corner of the table, out of the frame but still close at hand for technical assistance and conversation. The kitchen was also a hub of activity in many homes (Graesch 2013), with siblings and parents (or grandparents) frequently entering and exiting, making it a strategic location for participating children to solicit help from knowledgeable family members when needed (Fig. 1). Q9

An important final note about these task settings was that they sometimes included a collection of heterogeneous household items not necessarily relevant to the study or the task per se. These objects, such as handheld game consoles, smartphones, snacks, pets, and placemats all interacted with participants and also inscribed themselves into the task. While these peripheral materials did not end up in the digital maps, their traces remain in the video record, and their presence contributed to what was a decidedly "un-task-like" feeling of CTM. Participants- and their adult collaborators- reported enjoying CTM, and this was likely partly due to the relatively uncontrolled and comfortable atmosphere of studying families in their own homes (Goodwin and Goodwin 2013). Therefore, while we refer to CTM as a "task" throughout this analysis, it was perhaps more an activity "setting," in Lave's (1988) sense, that resulted from the relation between the quotidian, durable aspects of the environment and the situated actions of participants and researchers. In this way, CTM responds to a challenge to not only design adequate CSCL pedagogical tools and settings, but also interactive *situations* that invite deep learning (Cress et al. 2015).

Participants

Twelve children (boys and girls, Caucasian and African American) between the ages of nine and thirteen years old participated in this task. They were recruited for the larger study of young people's media and technology use that took place in a large Midwestern city over the course of one year. Some of the participants lived in the same or geographically close neighborhoods, and several of their maps involved overlapping areas, though of course, they were not privy to this. They had lived in their current neighborhoods for varying amounts of time, one family having just moved to the city in the months prior to participating in the study. Of the twelve participants, four (two pairs of sisters) were siblings. One of these sibling pairs collaborated in Community Technology Map

Fig. 1 Theo (wearing a GoPro head camera) and his Mom search for their house in Google Earth on the researcher's laptop. Theo placed his smartphone next to the computer for music

producing one map, while the other pair collaborated but created two separate maps. The majority of the families were enrolled during the school year, and observations and interviews took place after school or on weekends.

Data collection

The data for the CTM task consist of video recordings of children's mapping activities recorded on an HD camera positioned adjacent to or just behind the children as they mapped places in Google Earth. A few children wore GoPro head-mounted cameras, which captured children's own "coherent" angle of vision on the computer screen (Umphress and Sherin 2015). Because it was important to have an accurate image of how participants navigated the maps on screen, we utilized screen capture software to record the mapping process. We also video recorded the interviews of participants and their parents about the maps, once they were completed. Over fifteen total hours of video were reviewed for the present analysis.

Data analysis

The first step in our analysis was to content log all video recordings. Next, we drew on a grounded theoretical approach (Bryant and Charmaz 2007; Glaser and Strauss 1967) and engaged in open coding to iteratively develop the following descriptive categories for children's in-task activities: *remembering*; *selecting*; *locating*; *marking*; *tracing*; *navigating*; *narrating*; *negotiating*; *maneuvering*; *interrogating*; *course-correcting*; *scaling*; *homing*; *noticing*; *ground-truthing*; *evaluating; reconciling*; *associating* (relating things to places); *storying*; *historicizing*; *dis-placing*. Though we did not aim to generate a formal grounded theory, we utilized the analytic tools of this methodological approach to develop theoretical sensitivity (Glaser & Strauss), which allowed us to select or sample from the corpus instances of activities in CTM that warranted further analysis. We continuously went back to review the video data in group video-viewing sessions to develop codes and categories of activities. As these forms of activities were developed, we grouped overlapping activities into a few higher-level processes that were present in all children's mapping and pervaded the task: making places visible; making places coherent; and making places mobile. For example, the process "making places visible" involved the lower level activities selecting, *locating*, *marking*, *tracing*, *scaling*, and *noticing*.

Simultaneously, while we were developing this preliminary theoretical framework for categories of activities, we examined representative instances with a finer granularity (Shapiro et al. 2017). We conducted interaction analysis (e.g., Hall and Stevens 2016; Hontvedt and Arnseth 2013) of "hotspots" that occurred in the videos (Jordan and Henderson 1995, p. 43), instances in which the higher-level processes were particularly salient. From these, we created multi-modal transcripts of representative instances that depict how words, gestures, body and hand movements, body position, and human-computer interactions hung together to enact *inscribing places*. Multi-modal analysis of interactions between young people and technology in the activity allowed us to look across communication channels young people used to convey meaning while mapping (Goodwin 2013). This helped us look beyond the surface of *what* people communicated in order to catch the "magic moments" when they collaboratively accomplished shared meaning with tools and artifacts (Cress et al. 2015, p. 111; Roschelle and Teasley 1995).

Because we were interested in how young people understood spatio-temporal aspects of their technology use outside the task, attending to the specific movements, gestures, body positions, and navigational strategies used in the task was a particular affordance of this analytic approach.

Analytic findings

The first requirement of this task was that children remember past experiences. Without remembering, there was no Community Technology Mapping task. During all phases of the activity, then, children needed to reconstruct their memories of their daily rounds (Erickson 2004). This involved first deciding which places were relevant and interesting enough (to them) to map. Most appeared to develop a timeline of their day, starting off at home, moving to the bus stop, then off to school, often to an afterschool activity nearby, and finally home again in the evening. Once these places had been plotted, children expanded their timelines to incorporate activities that took place more sporadically or on the weekends including attending church, visiting grandparents or cousins, or attending summer camps. To map these places, children developed strategies that made their places visible, made them coherent, and made them mobile. This involved re-producing a "cascade of inscriptions" (Latour 1986) as they went about representing their place-based activities.

Writing themselves into the map

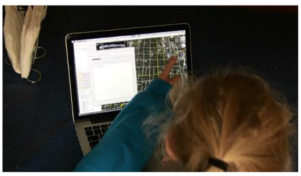
In order to create a map of places they tended to go, children had to figure out a way of making their daily or weekly itineraries visible. They had to bring to the present memories of past experiences in places they had been. These memories putatively resided inside their heads, and the task asked them to bring them out into the open on-screen where they could be seen and shared. To do so, they had to re-present absent places and make them visible. This meant that they had to first find the places on the map, which was neither simple nor straightforward. While some children found places by searching using Google Earth's in-app Search function, others did not always have searchable information like business names or addresses ready-to-hand. In these cases, children had to develop another strategy we call *wayfinding*. This other strategy of finding their way pervaded the task during all phases or prompts. Wayfinding is similar to what Ingold (2011) has called "wayfaring;" "the task of the wayfarer is not to act out a script received from predecessors but literally to negotiate a path through the world" (p. 162).

Wayfinding consisted of children scrolling through their neighborhood or nearby vicinities in order to find a place. Wayfinding involved a process of holding the place in mind and homing in on it while coordinating actions at the digital mapping interface. While some children used wayfinding to locate places and label them, others, in a later phase of the task, traced the path traversed during their wayfinding using Google Earth's drawing function; they literally inscribed a path on the map. Once they reached the intended places, children labeled them, often personalizing the path or place names, or writing themselves into the map. In what follows, we provide an example of how the Ichabod sisters trace (i.e. make visible) a path they routinely traveled during a typical week and use this to illustrate how inscribing places involved making them visible.

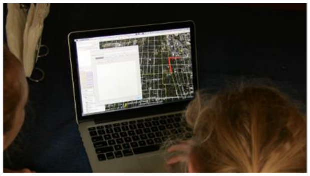
Tanya and Mary's wayfinding During this portion of their mapping, eleven-year-old Mary and her thirteen-year-old sister Tanya drew a pathway their parents typically drove to get home from the "the Y" (the YMCA, a community center) after the girls' swim practices. Prior to this drawing, the two had identified and labeled these two places and several others and had negotiated an arrangement whereby they took turns drawing pathways between places and labeling them. In order to draw pathways in Google Earth, it is necessary to have a dialog box open on screen. This enables the drawing feature, which overlays a line (here a thick red line) onto the map as they found their way between locations. It was Mary's turn to draw the pathway from the Y to home. However, before she could embark on the route, she had to figure out how to exit the Y parking lot, already visible on-screen.

Mary consulted her sister about this (line 1), and Tanya instructed her. Tanya narrated while Mary navigated, explaining how their parent drives them out of the parking lot and usually goes down the street until they reach "Ridge," a major thoroughfare (lines 2–3). They had the Street Names feature enabled, so they were able to read these on the map. No sooner had Mary begun wayfinding than she was abruptly stopped in her tracks as her older sister chastised her for missing the street where she needed to turn (line 3). Despite the ability to see where she was on the map, Mary's actions in-task brought an unfamiliar (untraveled) pathway into view for her sister. As Ingold (2011) writes "wayfaring always overshoots its destinations, since wherever you may be… you are already on your way somewhere else" (p. 162). Mary quietly acknowledged that she had indeed turned onto the wrong street, "Oh, woopsy," and she immediately closed the path drawing window and re-opened it to start the path again (line 4).

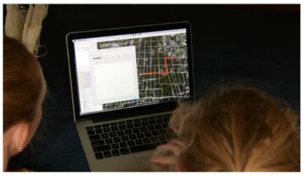
Mary: So we go out of the parking lot and then- do we- is it here?
Tanya: We go out of the parking lot and we usually go down um to this street I don't know where it is. Then we go down to Ridge. Mary, you went past Ridge!
Mary: (quietly) O:h, woopsy *((quits drawing path, re-opens drawing dialogue box))*.
Tanya: Ridge is right here, honey *((points at screen))*.
Mary: We go out of the parking lot and we go to here, and then we turn and go, (makes siren noise) wa-na-na-na-na-na. And then we go down this- then we stop at the stop light and then we go through the intersection….
Tanya: To:: Ashton. (2.0) No to:
Mary: Dewey.
Tanya: Yeah.
Mary: *((drags screen over to expose more of map, sisters giggle))* (sings) Mr. Grinch, da-na- na-na.



<5> Ridge is right here, honey



<7> We stop at the light



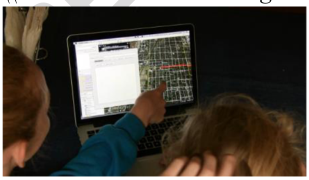
<12> *drags screen over*

On her second attempt, when she exited the parking lot, Mary turned onto Ridge and then continued wayfinding while playfully making a sound like an ambulance siren (lines 6–7). Tanya watched silently while Mary narrated and navigated. Mary explained that they usually stop at the light and then continue through an intersection (lines 7–8). She and her sister finished each other's sentences, "storying" their trail through the landscape (Ingold 2011), as they settled on the correct street on which they turn south towards home (lines 9–11). At this point, what was visible for them on screen was their starting point (the Y) and their destination (home); in an earlier phase of the CTM task, they had marked both of these places with yellow place markers and labeled them “YMCA” and “Mary and Tanya’s House,” respectively.

However, the path-drawing dialog box currently blocked their view of the street on which they needed to continue drawing the path southward. Paradoxically, while this “cascade of inscriptions” (Latour 1986)- i.e. the digital map- made their path drawable (and consequently discernible) it managed to disorient the sisters. Therefore, Mary needed to reposition her drawing tool with respect to this box, so that the map underneath was visible. In other words, so the map maintained a semblance of “optical consistency” (Latour, 1989) with the path she Q10 held in her mind. To do so, she opted to drag the screen to the right and up (line 12), effectively moving their house to a central position on the screen. While she did this, both girls giggled as Mary sang a silly song. At this point, it would seem that all there was left to do was to draw a straight pathway to their home, to literally home in on their house.

Tanya: Okay, so this is Ceril *((points at screen))*, so I think this is Dewey.
Mary: You’re right.
Tanya: Wait, why are you... wait why are we in the middle of the street?
Mary: (laughs) Oh: because-.
Tanya: That’s the alley, hon!
Mary: Ye:ah.
Tanya: So go, you just have to turn here.
Mary: *((turns the corner and continues drawing the pathway south))* Stop, move your hand.
Then we go around... uh-huh *((circles house with drawing tool))*. Ok. *((labels the path))*.


<14> I think this is Dewey


<18> That’s the alley, hon!


<22> *Types “We drive together”*

Like many children who participated in the CTM task, Mary’s wayfinding was neither simple, nor straightforward. First, based on their current location on the map, she and her sister had to decide which of two adjacent lines on screen was their street proper and which was actually an alley adjacent to it (lines 13–14). As Latour (1989) points out, on maps, “realms of reality that seem far apart are inches apart, once flattened out onto the same surface” (p. 26). When Mary’s wayfinding placed her on the latter route (the alley), Tanya redirected her once more, teasing her that “that’s the alley, hon!” Mary then adjusted her pathway slightly by drawing her way backwards towards the street and following Tanya’s advice to “turn here” (line 19). Tanya kept her finger in place on the proper street, as a placeholder, while Mary navigated towards it (line 19), eventually ordering her older sister to move (line 20); however, Mary was not able to see their house through her sister’s hand. At last, Mary circled around the block and back up the next street to arrive at their house (line 21). She then literally inscribed their house with the path-drawing tool by drawing a circle around it to close out her pathway. Finally, she labeled their path “from the YMCA to our home” and typed “we drive together” into the Description dialogue box (line 21–22). In these ways, the Ichabod sisters collaboratively inscribed their map by drawing paths, labeling places, and inserting descriptions.

Mary and Tanya encountered a number of obstacles while wayfinding home from the YMCA, and overcoming them entailed different strategies for making places visible. First, with her sister's helpful critique, Mary learned to use the visual cues provided by the Street Names to turn out of the parking lot onto the correct street. Then, Mary repositioned the drawing tool dialogue box, which obstructed a straight path between her position and her destination. This, however, was not trivial; moving the path-drawing dialogue box tripped up many other children's efforts at tracing a path, because clicking off a path in-progress in order to reorient the screen can easily produce an unwanted inscription (i.e. a mark) on the map. In this case, and to many children's dismay, the path had to be recreated from scratch.

Making their prospective path visible beneath the dialogue box was a critical moment in the sisters' task. It represents how, as Lammes (2016) wrote, digital maps involve users "co-shaping the alignment of immutable mobiles and co-producing the map image through the interface" (p. 11). But Mary's path forward was obscured again, this time by her sister's hand, requiring her to negotiate the inscription's visibility once more. Inscribing their own names and modes of transit (they "drive together") into the dialogue was their final strategy for producing a permanent, visible inscription of this pathway and its relevance in their daily round (Fig. 2). Q11

Summary Q12

Through the use of dialogue, gestures, and interactions with the GE interface, the sisters rendered their places visible by wayfinding. All these ways of finding and inscribing places served to highlight and bring awareness to the places that were important in children's daily

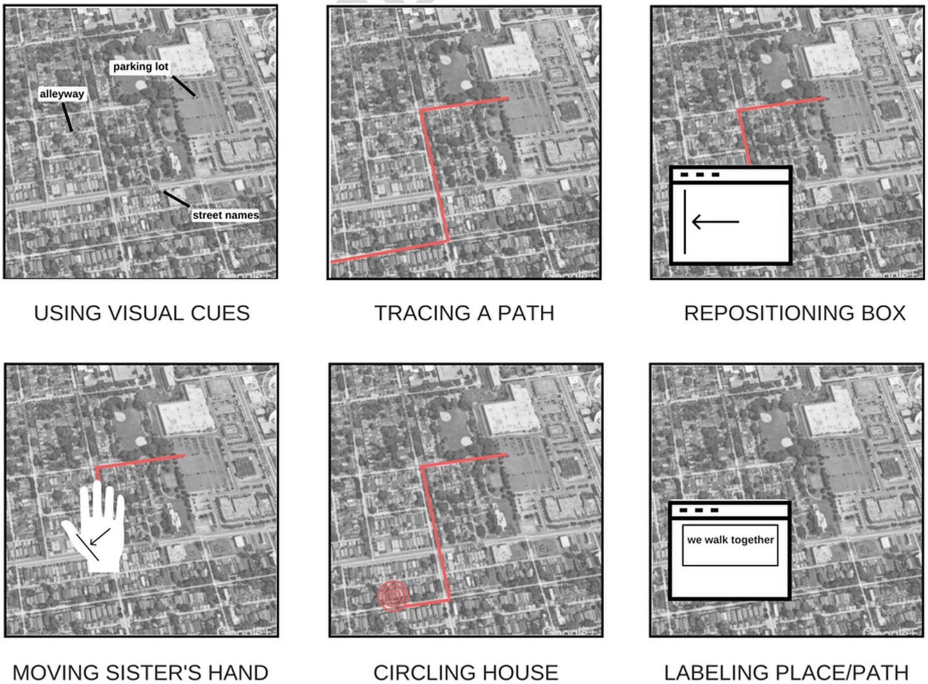


Fig. 2 Mary and Tanya's inscriptions and strategies for wayfinding *(for anonymity, map* approximates their actual location)

routines and revealed their spatio-temporal relationships. It made these places and relationships visible to children and to the researchers in and long after the task. However, though visible and durable, inscriptions have the contradictory effect of erasing all the complex work done to create them (Latour 1986, 1987). Furthermore, as maps become durable inscriptions (Latour 1991), they can constrain future inscriptions, as we saw when the relatively durable dialogue box (one layer of inscription) hindered the sisters' drawing of pathways (another inscription layer). In this regard, there is a unique advantage to having video recorded the CTM task: we were able to re-view the process of mapping in order to examine inscriptions as works in progress or "maps-in-the-making" (Gordon et al. 2016). Observing children's wayfinding, labeling, and describing at the level of moment-to-moment interactions showed us how inscriptions are evidence of techno-scientific controversies, especially when mapping collaboratively. Techno-scientific controversies take place when scientific perspectives on a matter of concern are being contended, before things are settled as matters of fact (Latour 1986), just as Tanya and Mary debated where to establish their pathway and precisely map their knowledge of their route home. The result of these contested moves and coordinated interactional processes were that children were able to make their places visible to us and to each other.

Inscriptions fundamentally engage writing practices (Latour 1986) and involve a visual language, to the degree that what gets written-in is visible and used to communicate (Rudwick 1976; Latour 1986; Wilson 2011). For today's digital map users, learning to use this language is part of developing locative literacies. As the case of Mary and Tanya illustrates, the main ways children made places visible and legible was to locate them through searching and wayfinding and to mark them by tracing paths and labeling places. And yet, something more personal appeared to happen when children inscribed the maps in these ways. They actually appeared to be *writing themselves into the map*, making their very personal and particular histories in places visible to us (and to them) through wayfinding (Ingold 2011). We saw this when they playfully narrated their itineraries while navigating through spaces. It was also apparent in the ways they chose to label, or to ascribe a place's name by inscribing it. One participant's local mall became "Leah's mall." Another boy's school was made "Theo's school." The Ichabod sisters annotated the place marker designating their path home from swim practice with the words "we drive together." In this way, locating places and pathways on the map and labeling them was more than a mere matter of re-inscribing the place name. Rather, children's mapping process entailed moments of making places their own, and naming them as such. Children thereby made places visible by writing themselves into the map.

Seeing through the map

Another process through which inscribing places took shape was the way children made their places coherent with past experiences in and of places. Making places coherent involved reconstructing narratives of places and reconciling a remembered place with a represented place. In order to remember and plot their experiences, children relied heavily on narrative strategies. Their talking and reasoning aloud (sometimes to themselves, often to collaborators) showed how part of making places by creating a map was making them coherent with a personal narrative or a life story under-construction (Linde 1993). While locating places and drawing pathways, children showed how they became aware of the presence of the natural and built environment inscribed or "incorporated" (Ingold 1993) in their memories of places–a spatial awareness made perceptible by the mapping task. However, the images of mapped spaces did not always necessarily cohere with children's memories of places. There are significant "asymmetries between interface producers and users" (Lammes 2016, p. 9), something children wrestled with in the context of CTM. At times, these struggles for coherence enabled them to see through the map to its (on-going) construction. In the following analysis, we show how Leah worked diligently to find coherence between her personal memories and the map before her eyes.

Leah locates Grandma's house Leah had been locating and labeling the places she frequently spent her time for roughly twenty minutes, when she decided to map her Grandmother's house in a town which is "so small" (line 1), where she visits every other month or so. Unsure of the address, she searched for the name of the town in the Google Earth search field and the map zoomed in to Shimmer Lake (line 3). It landed directly over the lake itself, and Leah leaned in closer to examine it, noticing the ice over the image of the lake, and noting that "this must be winter" (line 3). She commented that the surface of the lake had an interesting ice formation (line 6). The researcher (R) agreed and asked her where Shimmer Lake is (line 7), to which Leah replied glibly that it is "in the middle of nowhere" (line 8). Leah scrolled away from the lake to an adjacent residential neighborhood (line 10). Demonstrating her perspective on the remoteness of this small town, Leah joked that she "didn't think they had street names" (line 10). Both the ice on the lake and the presence of street names disrupted Leah's first-hand knowledge of these places, knowledge which did not appear to "fit" in the geometric space of this map (November et al. 2010).

Leah: I go to my Grandmother's house which is in Shimmer Lake, which I know is so small.
R: (laughs)
Leah: Alright, alright *((zooms into map, moves close to screen))*. So here's- oh, this must be winter.
R: Hmm.
Leah: That's an interesting ice formation.
R: Yeah, for sure. (3.0) Where is Shimmer Lake?
Leah: It's in the middle of nowhere.
R: (laughing) Is it?
Leah: *((moving the map around on the screen))* I didn't think they had street names.
R: (laughs)
Leah: Well here's a river, their house is kind of by a river.
R: You can approximate if you want.
Leah: Because I know there is a sign "dead end road."
R: Um-hm.
Leah: *((leans close to screen, points with mouse))* I think it's this one.
R: Um-kay.
Leah: *((still staring at place mouse is pointing))* Um:::. Actually it's not.
She has like a huge garage. *((moves map down to view a nearby street, locates another house))*. This is probably it.

Having explored these surprising elements depicted on the map, she then began searching for her grandmother's house in earnest. First, she seemed to be orienting to a nearby natural feature, mentioning that her grandmother's house is "kind of near a river" (line 12). When the researcher suggested that Leah could just "approximate" the location (line 13) and drop a pin in the general vicinity of where the house might be, Leah nonetheless persisted. She continued searching and commenting on signposts and landmarks that would help her find the place that was consistent with her grandmother's house, such as a dead-end sign (line 14) and a huge garage (line 19). Even when she thought she had located an aerial view of a house that matched her memory of this place, she hesitated to commit to it, reconsidering when the house's garage did not appear large enough (line 18). Finally, Leah settled on a house that satisfied her interest in marking a place sufficiently similar to the one of her memory (line 18). While we are still uncertain whether she found the "correct" house, her actions in-task signaled how "the correspondence between maps and lands is made *in practice* [italics in original] (November et al. 2010, p. 585).

Leah's persistent efforts to locate the "right" place despite the confusing or contradictory evidence provided by the map illustrated how centrally important coherence was to her mapping process. It was virtually inconceivable (to her) that she settle for an approximate place, when Google Earth made it "virtually" conceivable to locate very precisely which house was part of her itinerary. The specificity with which she approached her place-making speaks to how all children narrated their places while navigating to them. The stories they told conveyed rich and detailed experiences of being in places and of the nature of their activities in certain places. The CTM activity became a vital site for reconstructing storied places and for making places cohere with memories and embodied experiences (Ingold 1993).

At the same time, the map provided unusual, disorienting evidence of emplacement, such as ice formations, street names, a river, and a huge garage, information that contradicted her memory of this place (Fig. 3). Leah had approached the map as a truthful representation of a place she already thought she knew well, and she first searched for "supporting evidence" (Enyedy and Mukhopadhyay 2007) that reinforced her personal knowledge of her grand-mother's community. When her expectations of what she would find there pulled her up short (Kerdeman 2003), she struggled to bring a sense of stability and structure to things, and she noticed new facets of this place, which were not part of her incomplete memory of being there.

These digitally emergent elements of the built and natural environment updated Leah's understanding of this place in the CTM process. Emergent elements also provided a glimpse into the map's construction, which we call *seeing through the map*. As Ingold (1993) wrote, "the activities that comprise the taskscape are unending, the landscape is never complete: neither 'built' nor 'unbuilt', it is perpetually under construction" (p. 162). This backstage view of the construction of places through digital mapping software may have provided children glimpses not only into how places and maps are spatio-temporally contingent; it also conveyed to us how life stories (Linde 1993) or place-based histories (Gordon et al. 2016) are likewise always under-construction.

Summary

The critical geographer Harley famously noted that cartography is seldom what cartographers say it is (Crampton 2010). Maps reorganize space in ways that can contradict one's experience, requiring "ground-truthing" (Taylor and Hall 2013). When children encountered an image of their world that broke with familiar recollections of places, they appeared to experience a disorientation that needed to be reconciled. They worked to bring a semblance of coherent order to these images in a number of ways. Some played with the recalcitrant image as one would in a video game, noting the unsettling "creepiness" of the world that typically caused them little trouble. Other children analyzed the "representational infrastructure" (Star 1990), bringing into focus how the map was a sociotechnical construction by literally invoking the invisible work of Google Earth photographers and their vans. Latour (1991) suggests that the

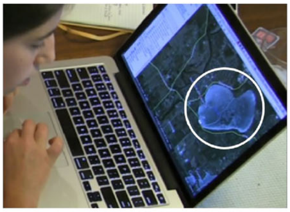
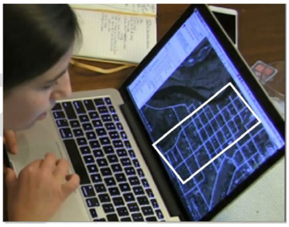
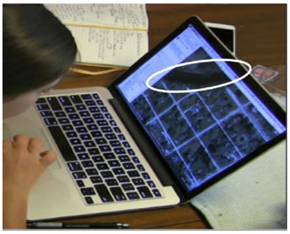
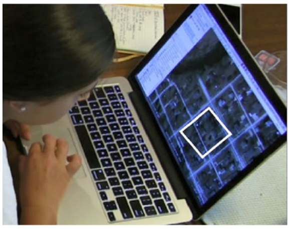
Remembered place	Mapped place	Leah's words	Map image
Shimmer Lake	Lake is frozen	<3> this must be winter	
Dead end road sign	Street names, roads	<9> I didn't think they had street names	
Kind of by a river	River nearby	<11>Well here's a river	
Has a huge garage	Small garage	<18> This is probably it	

Fig. 3 Leah works to bring coherence to her map

power of inscriptions rests on their heterogeneous "representatives" lining up and "speaking" with one voice (Callon 1986). According to this view, the efforts of children during CTM were effectively attempts to reassemble all the disparate actors who suddenly appeared to have incoherent interests, such as street signs, lakes, garages, Google Earth images (and photographers), and the digital mapping interface itself.

Still other children pointed out to their collaborators how a given feature of the built environment or the landscape had changed over time, considering the technology's image history while simultaneously narrating their own. For example, when Leah noticed the ice over Shimmer Lake, she brought forth not only the lake's changing temporality but also the *image's* history. Lammes (2016) points out that in "Google Earth, hinging as it does on a multitude of visible and re-combinable layers, the status of the image has changed" (p. 8). Seeing the image of the frozen lake from the bird's eye view of Google Earth disrupted Leah's otherwise coherent impression of this place. Having seen through the map in this way, Leah's narrative of this place was changed. Now it was a place that underwent seasonal change. Similarly, it became a place designated by street names. These new stories she told herself about this place created a new version of her place-based narrative, one no less coherent but certainly changed. It was as if, rather than forcing the recalcitrant images or inconsistent evidence back into alignment, she was translating (Latour 1986) or modifying the text of her narrative into the dynamic context of the task, "for the forms of the landscape arise alongside those of the taskscape, within the same current of activity" (Ingold 1993, p. 162).

These changes in perception reflect children's learning, particularly their learning about spatio-temporal relationships to place and about the representational power of socio-technical systems (Star 1999). These are important criteria for developing locative literacies. On the one hand, seeing through the map allowed Leah to see how the map-making had taken place at a particular time; on the other hand, she perceived familiar places differently because of their appearance on the digital map. This suggests that seeing through the map also enabled Leah to see through her preconceptions of place (i.e. that it was a town so small it lacked even street signs) to an emerging reality in which she saw Shimmer Lake anew, perhaps as a place defined by heterogeneous spaces (Leander et al. 2010) and across scales of time (Lemke 2000). Furthermore, CTM allowed us to see how these places were not anonymous place-holders in a child's routine (i.e. "the mall," "Grandma's house," or "school"). They were meaningful and storied places inflected by children's rich experiences in and of them. While for the researcher, Leah could have "approximated" place by dropping her pin on any house in Shimmer Lake, for Leah it was pivotal that her place be found, for only a specific place was coherent with her experience of being there.

Everything is on-the-move

While, we have so far illustrated how digital mapping, specifically Google Earth, reconfigures or re-mediates children's cartography in many ways, we would emphasize that any consideration of their interactions with digital maps must account for children's mobilities. As children went about making places visible and making places coherent during CTM, they were always enacting mobile ways of knowing (Leander et al. 2010; Taylor and Hall 2013; Taylor 2017). And the work of inscribing places mobilized all the sociotechnical work that had occurred upstream from the task (Latour 1986) that made it possible for children to interact with digital maps in the first place. We now turn to how children enacted mobility in place-making. In what follows, we describe the modes of mobility of one child who was in the process of tracing a route to a friend's house to illustrate how, to inscribe places, children moved across scales and negotiated displacements in the task.

Natalie engaged in wayfinding, the same strategy used by the Ichabod sisters, in order to find her way to her friend's house, an activity that took nearly twenty minutes (a full quarter of the total task time, and only ten minutes less than it does driving there in real time). In what follows, drawing from four sequential segments of Natalie's mapping we highlight how entangled modes of mobility- which we call the dynamic, corporeal, performative, and relational- allowed her to locate the right route to a destination. We argue that these tangled mobilities of digital mapping open up methodological and pedagogical opportunities for understanding the spatio-temporal organization of children's activities and for "mapping new mobilities" (Leander et al. 2010). We also describe how using GE technology reveals possibilities for heterogeneous sociotechnical processes- or inscriptions- to be mobilized in digital mapping (November et al., 2016). Q13

Natalie makes a mobile map Natalie had been scrolling down the highway towards her friend's house for close to five minutes when her mom finally signaled that Natalie had reached the exit- a cloverleaf- and directed her to get off the highway. As Natalie scrolled down, the screen image moved upwards. At the same time, the motion of Natalie's fingers on the track pad inadvertently caused the screen orientation to swivel, so that the cloverleaf, which she had avoided (it turns out, incorrectly) by taking a straighter exit pathway headed south-bound, rotated off the screen. Her mom then pointed up in the air above the computer, indicating a part of the map not visible on screen. She directed Natalie, "You need to go that way." The two debated this point. Natalie and her mom used the computer screen as the repository and reference for their gestures. However, the disorienting dynamics of the screen complicated easy navigating. As a resource or "substrate" on which they operated to come to a new shared understanding of this pathway (Goodwin 2013, p. 8), the dynamics of the computer interface needed to be negotiated. In a reversal of roles (and contrary to their everyday mobilities), Natalie was "driving," and so she had decisions to make about how to coordinate her body to make the turns and maneuvers that would keep her on the correct course towards her destination. Her mother copiloted by using the same deictic gestures common to families in automobiles, where the dynamics of attentional frames and rapidly changing visual cues are similarly complex (Goodwin and Goodwin 2012).

Of course, the dynamic experience of mapping in GE does not perfectly simulate lived mobilities; Natalie and her Mom drew upon bodies as semiotic resources (Hall et al., 2015) in Q14 order to come to a mutual understanding of the proper path through the exit ramp (Goodwin and Goodwin 2012). When Mom asked Natalie to remember which way they usually take off the exit, Natalie turned to look at her, taking her hands off of the trackpad and reorienting towards her mom in a new interactional frame. Accordingly, the researcher's camera angle rotated to face them, and Mom said, "We go on that circle up that way," gesturing somewhere between the computer screen and their bodies. Natalie disputed this, countering her mother's proposal by sweeping her own arm to the right and pointing in a slight clockwise direction. Natalie's sweeping arm was swiftly met by her Mom coupling to her daughter's body; Mom animated Natalie's arm (Goffman 1979), swinging it in a counter-clockwise direction. Natalie smiled, reluctantly resumed navigating, and returned to the point of the exit where the cloverleaves diverged. Arriving at an agreed upon heading through the exit involved re-animating corporeal experiences which had been inscribed in their bodies through the lived practice of having driven through this physical space (Taylor 2017). Their mobile bodies became mapping technologies available for inscribing places.

As the two continued to find their way, Natalie echoed her mom's narrated navigating, mimicking in a whispered, slightly sarcastic voice, "Okay, I'm getting off," while she exited the highway towards the cloverleaf once again. Her mom encouraged her to "keep following it." In a playful tone, Natalie humored her mom, "Yeah, this one, right here". However, she proceeded to take the same route as before, and her mom abruptly halted her, telling her to go back. Natalie slumped her shoulders and mock-cried, "I told you we went too far." She sang aloud as she dragged the screen along the arc of the cloverleaf, simulating the motion of driving around it and then onto the road to which it led off the highway. These negotiations between Natalie, Mom, and the screen laminated different modes of travel, agencies, and mobilities (Jensen, Sheller & Wind, 2014) within a single "performative cartography" (Verhoeff 2012).

Natalie, like several other young people in the study, played a number of roles, shifting back and forth between positioning herself as a confident and inexperienced "driver"; one minute, she was teasing her mom with false bravado, and the next she was foiled again by the interface. According to Verhoeff (2012), the interplay of feedback- the movement back and forth- between user and map that takes place at the computer interface makes mapping a performance rather than a pre-formed representation that is simply understood by the user. The screen was more than a display onto which a path was inscribed. The map interactively played with Natalie and her mom, producing a highly performative- and collaborative- cartographic experience (Fig. 4).

Natalie: Oh. Um. This is not it.
Screen: [((*continues moving down, on same road*))].
Mom: That is it.
Screen: [((*cars, buildings start to appear on screen*))].
Natalie: Oh maybe it is. Maybe that's a gas station?
Screen: [((*reaches an intersection, makes a turn, moving to left*))].
Mom: So that's the-.
Natalie: [and then-.

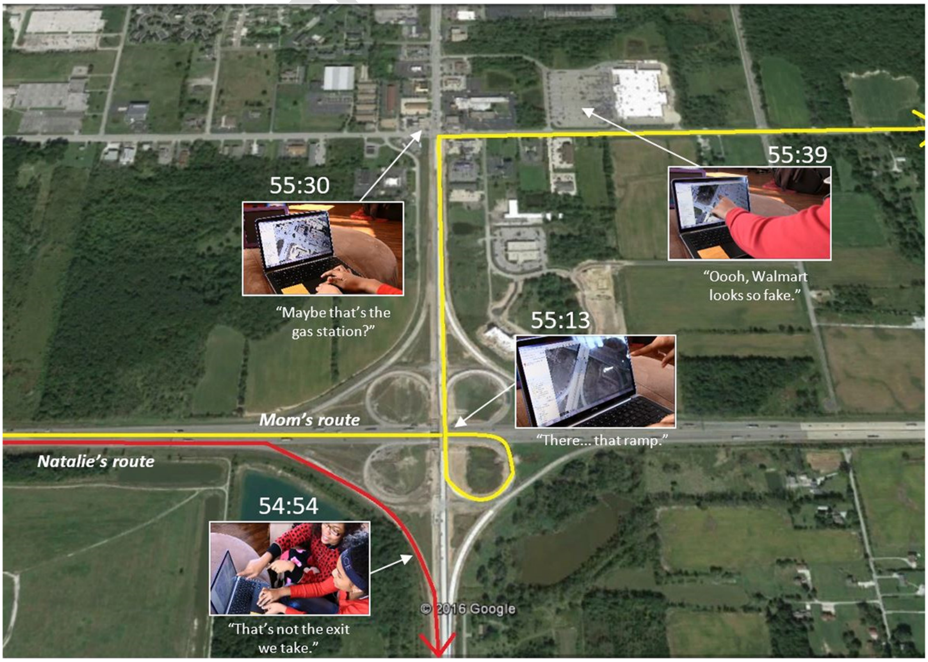


Fig. 4 Natalie and her mom negotiate a cloverleaf highway exit

Mom: [uh-huh.
Natalie: do we- yeah.
Mom: [yeah, here.
Screen: [((*large parking lot appears on screen*))].
Natalie: There go Walmart! Ooh Walmart looks so fake. Nobody ((*points*)) actually parks-.
Mom: (laughs) Yeah, they might have put that in there, that doesn't look too… well maybe-.
Natalie: Who would miss- who would miss that ((*points into screen*)) parking space?

Natalie did not at first recognize that she had made the right move off the highway, claiming that "This is not it" (line 1). When familiar objects like cars and buildings began to appear on the screen, Natalie mumbled softly that she may indeed be in the right place, suggesting "Maybe that's a gas station?" (line 5). She reached an intersection, automatically turning right, and she and her mom uttered, with increasing prosody, a series of short and over-lapping phrases related to what they were seeing on the screen and how Natalie was scrolling through this area (lines 7–11). With this rapid exchange, the two mutually established that they were in the right place, which Natalie demonstrated by enthusiastically exclaiming, "There go Walmart!" (line 13). Pointing at the parking lot on the screen, she claimed that the Walmart "looks so fake." Her mom laughed and offered an explanation that "They might have put that [image] in there" (line 14). Natalie warranted her claim by pointing emphatically at a parking space near the building and asking, "Who would miss that parking spot?" (line 15). In other words, the image must have been faked, because no real person would fail to park in such a prime parking spot. Natalie's disbelief is reminiscent of what we observed Leah and other participants do when confronted with map images that did not ring true to children's familiar experiences in places.

Although she was finally headed the right way, Natalie continued to appear displaced. It was only once she started to relate her location on the map to the objects in the built environment that she seemed to regain a sense of connectedness to this location. She relied on these relational cues, formerly inscribed in her experience of being in this place, to ground her position on the map. And yet, this relational strategy, a kind of virtual ground-truthing, only got her so far. No sooner had she established firm footing in this place, then a disruption to the authenticity of the map again displaced her, and she started to doubt the "status" (Lammes 2016) of the Google Earth image of Walmart.

This suggests a more profound displacement at work here. In seeing through the map, Natalie called up all the work that had gone into making it. Even her Mom invoked the former presence of some other actors, when she suggested that "they" must have just placed the "fake" image of Walmart's parking lot into the map. The relations between heterogeneous actors were momentarily made visible, re-mobilized by the mapping process (November et al. 2010). The transparent reliability of the map was questioned, and Natalie and her Mom saw through it to its construction. It was only through this active and processual mapping "event" that the contingent relations between Natalie, her Mom, the computer interface, the highway, a gas station, Walmart, and the Google Earth photographers emerged. By finding her way to her friend's house Natalie "drew together" (Latour 1986) or re-mobilized an assemblage of dis-placed actors and infrastructures, making them all visible once again and re-inscribing relations with them through interactive digital mapping.

Summary

Natalie's mobile activities and virtual places performatively co-produced each other (Verhoeff 2012). Natalie's mobilites surfaced how heterogeneous associations or relations between people, objects, and contexts are implicated in sociotechnical systems often treated as transparent or naturalized, a realization Bowker and Star (1999) refer to as "infrastructural inversion." Through a cascading series of displacements of materials and people, a durable inscription like a map can stand for complex experiences and socio-technical processes (Latour 1986). The interleaving of multiple aspects of mobility- dynamic, corporeal, performative, and relational- was part of inscribing places. By drawing together the heterogeneous actors- cars and busses, Walmarts, highways, parents and siblings, frozen lakes, satellites in space, people who take Google Earth photos, laptop computers, researchers, and young children- complex socio-technical systems got reduced to single, transportable digital maps, which we then took back to our labs and analyzed.

The maps generated in CTM were immutable and mobile (Latour 1986); children created permanent maps of their daily activities that we were able to review in analysis of these data. Yet, if we take a closer look at the CTM task and the process of mapping–something we can do because of the enduring nature of video-recorded data–we see a less stable arrangement of place and space. The places kids mapped were literally on the move as they flew, zoomed, and scrolled through Google Earth. The ability to create traces and mark-ups of children's experiences on a readable (digital) page was made possible by the dynamic, interactive nature of Google Earth. The ability to move through space virtually in ways that were typically off limits, to change scales (by zooming in or out), to modify perspectives (i.e. in street-view) was entirely technologically mediated. CTM allowed children to make places mobile in all of these ways, while remaining more or less stationary in the comforts of their homes. But it also put some of the maps "immutability" back into circulation by bringing into view how maps are dynamic and unstable (sometimes unbelievable, as in Natalie's skepticism regarding the Walmart parking lot) representations of space. In this task, *everything was on the move.*

Discussion

This paper has examined a novel research activity called Community Technology Mapping. Children created maps or inscriptions of their regular activities which involved personal and collaborative (re)constructions of actual places and lived experiences, which were then written-in to the virtual map. In doing so, they were inscribing places. We have described how inscribing places involved processes of making places visible, making places coherent, and making places mobile. We now turn to a discussion of how inscribing places served young people and how it served researchers by highlighting what we see as the key pedagogical and methodological affordances of the task. We end by offering what we believe are important contributions of CSCL approaches like this to developing locative literacies and the implications of locative literacies to learning more broadly.

CTM served several pedagogical purposes. First, it allowed children to produce a spatial and temporal representation of their movements and itineraries. This mobilized a new spatio-temporal language for their perceptions of daily life, a new way of seeing their relationship to their world (Latour 1986; Lammes 2016). CTM created a space (in their homes) in which children's shifting understandings of the spatiotemporal organization of the world (outside of the home) temporarily unfolded, bringing into perspective for them how their everyday activities have technology folded into them. By and large, children in the study were surprised to see they did not regularly go to all that many places; perhaps this is related to their age, but it is also indicative of a troubling new relationship some perceive between digital media use and adolescents' social isolation (Twenge 2017). As a CSCL pedagogical approach, CTM makes it possible for children to produce new artifacts or representational resources to use in their learning (Stahl et al. 2014), specifically in learning how their activities are spatio-temporally organized.

A second pedagogical affordance of the task involved the interactive, digital medium of Google Earth itself. The task offers new possibilities for developing locative literacies because of the use of this novel medium for generating place-based narratives based in young people's lived experiences, one which is not fixed but editable (Gordon et al. 2016). Digital mapping adds a dynamic dimension to traditional paper maps as tools for surfacing and building on children's emerging understandings of place. Had we provided children with a paper map of their neighborhood and a pencil and asked them to draw their pathways and label their places, the complex dynamics of navigating through virtual space would not have been available. Creating new interactional and mediational spaces in which collaboration can take place is part of the on-going work of designing CSCL pedagogical approaches (Roschelle and Teasley 1995). We see CTM as part of a new ensemble of learning arrangements for developing locative literacies (Taylor et al. 2017b; Taylor & Silvis, 2017).

A third pedagogical move- less obvious to some children, though puzzling and potentially transformative for others- was the emergent disclosures of the "backstage" work and invisible infrastructures of digital maps (Star 1999). As young people engaged in interactive digital mapping, they pried open "black-boxes" (Latour 1986) sealed tightly by the powerful illusion of images' authenticity. It was simply not the case that when children brought their places and pathways out into view to be mapped, that these were then perfectly recognizable to them. Rather than re-presenting the immutability of mapped space, the CTM task showed something quite different; it revealed the invisible work that makes inscriptions appear in the first place and then appear immutable (Lammes 2016). As children generated these representations they effectively tested the map's truthfulness as a representation of space. Inscribing places allowed participants to see through the map to its construction. While CSCL pedagogical approaches have been particularly useful for helping young people visualize valued content in new ways (e.g. Ryokai and Agogino 2013; Shapiro et al. 2017; Zahn et al. 2012) the ways technologies can also embed these same value systems *invisibly* has gone relatively unquestioned. CTM attempts to intervene by providing a computer-supported approach for collaboratively interrogating cartographic inscriptions specifically, but digital ones more broadly.

Controversies emerged in the negotiations between mappers and their collaborators, and inconsistencies between the map's image and the mapper's experiences made the hidden work of inscription visible (Latour 1986), supporting children to adopt new critical stances towards the map. Whereas one minute Natalie navigated past her Walmart, suddenly the parking lot looked fake and she found that instead she was seeing "Walmart." This "movement towards abstraction" recalls Latour's (1999) work with pedologists and botanists in the Amazon, in which he showed how they had gone to the forest of Boa Vista and brought back with them in their soil samples the "forest of Boa Vista," which the scientists subsequently wrote into their papers in incessant chains of inscription. In this same way, the current paper might be seen as part of an on-going inscription process that includes Google Earth technology, the CTM task, and all the actors that continue to participate in this particular chain of inscriptions long after the task's completion. Even our data are on-the-move (Radinsky 2017).

As a methodological tool, CTM first made visible to us how children organized their daily routines and made sense of their everyday activities through local material arrangements beyond their homes. The task externalized, through talk and interactions with the technology, children's past experiences as already inscribed by places and things (Chi 1997). CTM allowed researchers to see how the material environment had written itself into children's remembered experiences, an aspect of learning that is often hard to tap into in traditional learning situations. This is consistent with recent work in children's geographies (e.g. Gordon et al. 2016; Jenson et al. 2015; Taylor 2017) that focuses on how emerging forms of mobility support new relationships to places and offset a potential consequence of children's declining independent mobility (Barker et al. 2009). In CTM, the knowledge of young people was a resource for understanding the rich details of the physical environment they perceived during their daily rounds across even short distances and at hyperlocal scales.

CTM also revealed to us certain spatial exigencies of late childhood mobilities such as staying on the sidewalk, walking to the bus stop, being driven to sports practice, and beginning to taste the freedom of walking with friends to the local coffee shop on a major thoroughfare. These mundane, yet personal insights are important for understanding families' changing mobilities (Jenson et al. 2015). Allowing young people to write themselves into the map was one way of eliciting these incidental phenomena in their first-person accounts. Whereas young people may not have seen these details as relevant to researchers' broader scientific interests in place, mapping, and technology use, we were given a more textured view of children's experiences because they literally took us through the steps of their daily rounds.

In addition to showing us what young people did do (or had to do because their parents or school required it), we saw what children wished they could do. CTM permitted young people to go "off the grid" for a brief moment and explore places or modes of transit that defied their parents or the laws of physics. CTM allowed us to see a version of children's accounts which live reenactments (Pink et al. 2016) of these same routines could fail to capture, because young people might sanitize their activities for the camera. CTM gave us a window into their playful performances like wandering off the sidewalk into the virtual street or pretending to drive down the highway when they were too young to legally be behind the wheel. These rare glimpses of hoped-for mobilities are important for understanding place and space from a youth perspective, linking to imagined, possible geographies of opportunity (Tate, 2008). Q17

Finally, in the context of a study of how mobile technology and new media are incorporated in the everyday lives of our young participants, the maps they created and then talked over in follow-up interviews revealed how technology is embedded in how young people spend their time. Had we simply used a paper map to plot the same locations and trace the same routes, we would have lost an opportunity to observe a novel instantiation of the increasing technological saturation of children's home lives (Pink and Mackley 2013), an important site for developing locative literacies. While the CTM recordings and digital artifacts contribute to substantive analyses of children's technology use, the current analysis has shown that this is also methodological evidence of how we might continue to develop new methods for mapping children's mobilities (Leander et al. 2010). CTM points to how data and methods on learning in a networked age are also on-the move (Radinsky 2017).

Conclusion

Google Earth and other interactive mapping applications provide a platform for learners to examine the relationship between how learning is place-based and technologically mediated. As a methodological tool, moreover, the task revealed how places are not given, and they are not stable sites of shared meanings. Places are made through collaborative socio-technical work, and “everything is on the move” (November et al. 2010). The points of interest, relationships between places and things, and dynamic movements of childhood are merely provisional. These too, are on-the-move through space, in time, and across everyday activities.

At this particular technological moment, when digital mapping applications are rapidly replacing paper maps, we might reflect on whether young people a decade from now will ever have the experience of unfolding a paper map or spinning a globe to learn something about the world. In a networked era, children’s daily lives are shaped by digital maps and the logic of space informed by them. It is these ways of knowing- and more importantly, of re-shaping cartographic knowledge- that locative literacies make available. This new form of literacy will be an important component of global and digital citizenship as more people and places come online in a digital environment saturated by geolocative technologies (Elwood and Leszczynski 2012; Taylor & Silvis, 2017). As Leander et al. (2010) wrote,

> “Gaining an understanding about where you are in the world promotes realizations of where others are in relation. Targeting the spatial aspect of learning is thus an important way of promoting democratic values and citizenship” (p. 356).

Geospatial technologies present new means for learners not only mapping places but collaboratively examining the construction of places as consequential for learning. As a novel pedagogical approach for CSCL, CTM contributes to our repertoire of contexts for learners to create artifacts and representational resources using emerging digital technologies (Stahl et al. 2014). We have situated this task in homes, but also see how it could be applied in multiple pedagogical contexts given the ubiquity of platforms like Google Earth and the rapid proliferation of mobile mapping applications more broadly. Given the place-based orientation of this particular pedagogical approach to CSCL, significant dimensions for design adaptations will include spatial, temporal, social, and mediational contingencies of the interactional spaces where CTM is enacted (Roschelle and Teasley 1995). What relationships inhere between participants and other potential CTM settings? How might conducting CTM outside of the home serve to center community-based aspects of Community Technology Mapping in ways that may be constrained by taking individual people’s homes as starting points? These strike us as important pedagogical considerations for moving CTM out into children’s broader learning environments and continuing to study learning as a place-making process.

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Appendix: CTM Interview Protocol

Open Google Earth:

- Have participant type in their home address in the search field
- Ask participant to insert placemarker in location of home and label whatever they want (but preferably something that we know means "home).
- Ask P to mark with placemarkers and name all of the typical places they go to in the course of a week.

– While they are doing that, pay attention to *how* they are doing that – are they following streets, zooming in and out?

- Now, ask participants, if they can, to mark the pathways they take between locations.
- Ask P to identify the places that they've marked where it would be most likely for them use technology.
- Ask P to identify the places that they've mapped where they have the most fun, or feel the most engaged.
- "Fly" to each place that they've marked and ask:

– Who are you typically with in this place?
– What are you usually doing in this place?
– When you're not in this place, is there anything you miss about it?
– When you are in this place, who are you with?
– When you're in this place, what are the different activities that you're doing?
– When you arrive and leave this place, by what means of travel are you doing so?

- Along pathways between places you go, do you ever use media and/or technology?

– If so, are there particular pathways? On what does it depend?
– What kind of media do you use in these "moving" moments?

References

Barker, J., Kraftl, P., Horton, J., & Tucker, F. (2009). The road less travelled- new directions in children's and young people's mobilities. *Mobilities, 4*(1), 1–10.

Barron, B., Martin, C. K., Takeuchi, L., & Fithian, R. (2009). Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media, 1*(2), 55–77.

Bingham, N., & Thrift, N. (2000). Some new instructions for travelers: The geography of Bruno Latour & Michael Serres. In Crang & N. Thrift (Eds.), *Thinking Spaces*. New York: Routledge.

Bowker, J., & Star, S. L. (1999). *Sorting things out: Classification and its consequences*. Cambridge: MIT Press.

boyd, d. (2014). *It's complicated: The social lives of networked teens*. New Haven: Yale University Press.

Bryant, A., & Charmaz, K. (2007). Grounded theory methods and practice. In A. Bryant & K. Charmaz (Eds.), *The SAGE handbook of grounded theory*. SAGE: Los Angeles.

Callon, M. (1986). Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St. Brieuc Bay. In J. Law (Ed.), *Power, action, and belief: A new sociology of knowledge?* (pp. 196–233). London: Routledge.

Cazden, C., Cope, B., Fairclough, N., Gee, J., et al. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review, 66*(1), 60–92.
Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *The Journal of the Learning Sciences, 6*(3), 271–315.
Cole, M. (2006). *The fifth dimension: An after-school program built on diversity*. New York: Russel Sage Foundation.
Cole, M., & Griffin, P. (1983). A socio-historical approach to re-mediation. *Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 5*(4), 69–99.
Crampton, J. W. (2010). *Mapping: A critical introduction to cartography and GIS*. Wiley-Blackwell.
Cress, U., Stahl, G., Ludvigsen, S., & Law, N. (2015). The core features of CSCL: Social situation, collaborative knowledge processes and their design. *International Journal of Computer-Supported Collaborative Learning, 10*, 109–116.
diSessa, A. A. (1997). *Changing minds: Computers, learning, and literacy*. Cambridge: MIT Press.
Ellegård, K., & Hägerstrand, T. (1977). Activity organization and the generation of daily travel: Two future alternatives. *Economic Geography, 53*(2), 126–152. Q20
Elwood, S. (2010). Geographic information science: emerging research on the societal implications of the geospatial web. *Progress in Human Geography, 34*(3), 349–357.
Elwood, S., & Leszczynski, A. (2012). New spatial media, new knowledge politics. *Transactions of the Institute of British Geographers, 38*, 544–559.
Enyedy, N. (2005). Inventing mapping: Creating cultural forms to solve collective problems. *Cognition and Instruction, 23*(4), 427–466.
Enyedy, N., & Mukhopadhyay, S. (2007). They don't show nothing I didn't know: Emergent tensions between culturally relevant pedagogy and mathematics pedagogy. *The Journal of the Learning Sciences, 16*(2), 139–174.
Erickson, F. (2004). *Talk and social theory: Ecologies of speaking and listening in everyday life*. Cambridge, UK: Polity Press.
Erstad, O. (2012). The learning lives of digital youth-beyond the formal and informal. *Oxford Review of Education, 38*(1), 25–43.
Farman, J. (2010). Mapping the digital empire: Google Earth and the process of postmodern cartography. *New Media & Society, 12*(6), 869–888.
Freire, P., & Macedo, D. (1998). Literacy: Reading the word and the world. *Thinking, 14*, 1.
Friedman, T. L. (2016). *Thank you for being late: An optimist's guide to thriving in the age of acceleration*. New York: Farrar, Straus & Giroux.
Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.
Gee, E., Takeuchi, L. M., & Wartella, E. (Eds.). (2017). *Children and families in the digital age: Learning together in a media saturated culture*. New York: Routledge.
Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick: Aldine Transaction Publishers.
Goffman, E. (1979). Footing. *Semiotica, 25*, 1–29.
Goldman-Segall, R. (1998). *Points of viewing children's thinking: A digital ethnographer's journey*. Mawah, NJ: Lawrence Erlbaum Associates.
Goodchild, M. F. (2008). What does Google Earth mean for the social sciences? In M. Dodge, M. McDerby, & M. Turner (Eds.), *Geographic visualization: Concepts, tools, and applications*. Hoboken: Wiley.
Goodwin, C. (1994). Professional vision. *American Anthropologist, 96*(3), 606–633.
Goodwin, C. (2013). The co-operative, transformative organization of human action and knowledge. *Journal of Pragmatics, 46*, 8–23.
Goodwin, M. H., & Goodwin, C. (2012). Car talk: Integrating texts, bodies, and changing landscapes. *Semiotica, 191*(1), 257–286.
Goodwin, M. H., & Goodwin, C. (2013). Nurturing. In E. Ochs & T. Kremer-Sadlick (Eds.), *Fast-forward Family: Home, work, and relationships in middle-class America*. Berkeley: University of California Press.
Gordon, E., Elwood, S. & Mitchell, K. (2016). Critical spatial learning: Participatory mapping, spatial histories, and youth civic engagement. Children's Geographies. Q21
Graesch, A. P. (2013). At home. In E. Ochs & T. Kremer-Sadlick (Eds.), *Fast-forward family: Home, work and relationships in middle-class America*. Berkeley: University of California Press.
Haddington, P., & Keisanen, T. (2009). Location, mobility, and the body as resources in selecting a route. *Journal of Pragmatics, 41*, 1983–1961.
Hall, R. & Stevens, R. (2016). Interaction analysis approaches to knowledge in use. In A.A. diSessa, M. Levin, and N.J.S. Brown (Eds.), Knowledge and interaction: A synthetic agenda for the learning sciences. New York: Routledge.
Hall, R., Ma, J. Y., & Nemirovsky, R. (2015). Rescaling bodies in/as representational instruments in GPS drawing. In V. Lee (Ed.), *Learning technologies and the body: Integration and implementation in formal and informal learning environments*. New York: Routledge.

Haraway, D. (1988). Situated knowledges': The science question in feminism and the privilege of partial perspective. *Feminist Studies, 3*, 575–599.

Hart, R. (1977). *Children's experience of place: A developmental study*. New York: Irvington Publishers.

Higgins, S. E., Mercier, E., Burd, E., & Hatch, A. (2011). Multi-touch tables and the relationship with collaborative classroom pedagogies: A synthetic review. *Computer-Supported Collaborative Learning, 6*, 515–538.

Hontvedt, M., & Arnseth, H. C. (2013). On the bridge to learn: Analysing the social organization of nautical instruction in a ship simulator. *Computer-Supported Collaborative Learning, 8*, 89–112.

Ingold, T. (1993). The temporality of the landscape. *World Archaeology, 25*, 152–174.

Ingold, T. (2011). *Being alive: Essays on movement, knowledge and description*. London: Routledge.

International Society for Technology in Education. (2016). ISTE national educational technology standards (NETS). Retrieved from http://www.iste.org/docs/Standards-Resources/iste-standards_students-2016_one-sheet_final.pdf?sfvrsn=0.23432948779836327.

Ito, M., Baumer, S., Bittanti, M., boyd, d., Cody, R., et al. (2010). *Hanging out, messing around, and geeking out: Kids living and learning with new media*. Boston: MIT press.

Ito, M., Gutierrez, K., Livingstone, S., Penuel, B., Rhodes, J., et al. (2013). *Connected learning: An agenda for research and design*. Irvine: CA: Digital Media and Learning Research Hub.

Jenkins, H., Ito, M., & boyd, d. (2017). *Participatory culture in a networked era*. Cambridge, UK: Polity.

Jenson, O. B., Sheller, M., & Wind, S. (2015). Together and apart: Affective ambiences and negotiation in families' everyday life and mobility. *Mobilities, 10*(3), 363–382.

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practices. *Journal of the Learning Sciences, 4*(10), 39–103.

Kerdeman, D. (2003). Challenging self-understanding as a focus of teaching and learning. *Journal of Philosophy of Education, 37*(2), 293–308.

Kimiko, R., & Agogino, A. (2013). Off the paved paths: Exploring nature with a mobile augmented reality learning tool. *International Journal of Mobile Human Computer Interaction, 5*(2), 21–49.

Kingston, R. (2010). Mind over matter?: History and the spatial turn. *Cultural and Social History, 7*(1), 111–121.

Lammes, S. (2016). Digital mapping interfaces: From immutable mobiles to mutable images. *New Media & Society*, 1–15.

Latour, B. (1986). Visualisation and cognition: Thinking with eyes and hands. In H. Kuklick (Ed.), *Knowledge and society studies in the sociology of culture past and present*. Jai Press, 6, 1–40.

Latour, B. (1987). *Science in action*. Ch. 6, Centres of calculation, 215–257.

Latour, B. (1991). Technology is society made durable. In J. Law (Ed.), *A sociology of monsters: Essays on power, technology and domination*. London: Routledge.

Latour, B. (1999). Circulating reference: Sampling the soil in the Amazon forest. In *Pandora's hope: Essays on the reality of science studies.* Cambridge: Harvard University Press.

Lave, J. (1988). *Cognition in practice: Mind, mathematics & culture in everyday life*. New York: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Leander, K. M., Phillips, N. C., & Taylor, K. H. (2010). The changing social spaces of learning: Mapping new mobilities. *Review of Research in Education, 34*(1), 329–394.

Lee, V. R. (2015). Technology meets body, body meets technology. In V. R. Lee (Ed.), *Learning technology and the body: Integration and implementation in formal and informal learning environments*. NY: Routledge.

Lemke, J. L. (2000). Across the scales of time: Artifacts, activities, and meanings in ecosocial systems. *Mind, Culture, and Activity, 7*, 273–290.

Linde, C. (1993). *Life stories: The creation of coherence*. New York: Oxford University Press.

Ma, J. (2016). Designing disruptions for productive hybridity: The case of walking scale geometry. *Journal of the Learning Sciences, 25*(3), 335–371.

Ma, J. Y., & Munter, C. (2014). The spatial production of learning opportunities in skateboard parks. *Mind, Culture, and Activity, 21*(3), 238–258.

NGSS Lead States. (2013). Next generation science standards: for states, by states (interdependent relationships in ecosystems). Retrieved from http://www.nextgenscience.org/.

November, V., Camacho-Hubner, E., & Latour, B. (2010). Entering a risky territory: Space in the age of digital navigation. *Environment and Planning D: Society and Space, 28*, 581–599.

Patterson, T. C. (2007). Google Earth as a (not just) geography education tool. *Journal of Geography, 106*(4), 145–152.

Phillips, N. C. (2013). Investigating adolescents' interpretations and reproductions of thematic maps and map argument performances in the media. (Doctoral dissertation, Vanderbilt University).

Pink, S., & Mackley, K. L. (2013). Saturated and situated: Expanding the meaning of media in the routines of everyday life. *Media, Culture & Society, 35*(6), 677–691.

Pink, S., Horst, H., Postill, J., Hjorth, L., Lewis, T., & Tacci, J. (2016). *Digital ethnography: Principles and practice*. Los Angeles: SAGE.

Radinsky, J. (2017). Data on the move. Talk presented at Learning on the Move Workshop. Nashville, TN.

Roschelle, J. & Pea, R. (2002). To unlock the learning value of wireless mobile devices, understand coupling. *Proceedings of the IEE International Workshop on Wireless and Mobile Technologies in Education*. Växjö, Sweden.

Roschelle, J., & Teasley, S. (1995). The construction of shared knowledge in collaborative problem-solving. In C. E. O'Malley (Ed.), *Computer supported collaborative learning* (pp. 69–97). Heidelberg, Germany: Springer-Verlag.

Rudwick, M. (1976). The emergence of a visual language for geological science, 1760–1840. *History of Science, 14*, 149–195.

Santo, C. A., Ferguson, N., & Trippel, A. (2010). Engaging urban youth through technology: The youth neighborhood mapping initiative. *Journal of Planning Education and Research, 30*(1), 52–65.

Shapiro, B., Hall, R., & Heiberger, L. (2015). Assembling American roots music: Visitors' micro-curation and engagement in museum gallery spaces. *Paper presented at the Annual Meetings of the Association of American Geographers*, Chicago, IL.

Shapiro, B., Hall, R., & Owens, D. A. (2017). Developing & using interaction geography in a museum. *International Journal of Computer-Supported Collaborative Learning, 12*, 377–399.

Stahl, G., Ludvigsen, S., Law, N., & Cress, U. (2014). CSCL artifacts. *International Journal of Computer-Supported Collaborative Learning, 9*, 237–245.

Star, S. L. (1990). Power, technology and the phenomenology of conventions: On being allergic to onions. *The Sociological Review, 28*(1), 26–56.

Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist, 43*(3), 377–391.

Stevens, R. (2000). Divisions of labor in school and in the workplace: Comparing computer and paper-supported activities across settings. *The Journal of the Learning Sciences, 9*(4), 373–401.

Stevens, R., & Hall, R. (1998). Disciplined perception: Learning to see in technoscience. In M. Lampert & M. L. Blunk (Eds.), *Talking mathematics in school: Studies of teaching and learning* (pp. 107–150). New York: Cambridge University Press.

Takeuchi, L., & Stevens, R. (2011). *The new co-viewing: Designing for learning through joint media engagement*. A report of The Joan Ganz Cooney Center at Sesame Workshop and LIFE Center.

Taylor, K. H. (2017). Learning along lines: Locative literacies for reading and writing the city. *Journal of the Learning Sciences, 26*(4), 533–574.

Taylor, K. H., & Hall, R. (2013). Counter-mapping the neighborhood on bicycles: Mobilizing youth to reimagine the city. *Technology, Knowledge and Learning, 18*(1–2), 65–93.

Taylor, K.H., Takeuchi, L. & Stevens, R. (2017a). Mapping the daily media round: Novel methods for understanding families' mobile technology use. *Learning, Media and Technology,* 1–15.

Taylor, K. H., Silvis, D., & Stevens, R. (2017b). Collecting and connecting: Intergenerational learning with digital media. In E. Gee, L. M. Takeuchi, & E. Wartella (Eds.), *Children and families in the digital age: Learning together in a media saturated culture*. New York: Routledge.

Twenge, J. (2017). Have smartphones destroyed a generation? *The Atlantic*. September. Q22

Umphress, J., & Sherin, B. (2015). The body as viewfinder: Using wearable cameras in learning research. In V. Lee (Ed.), *Learning technologies and the body: Integration and implementation in formal and informal learning environments*. New York: Routledge.

Verhoeff, N. (2012). *Mobile screens: The visual regime of navigation*. Amsterdam University Press.

Vertesi, J. (2008). Mind the gap: The London underground and the users' representations of urban spaces. *Social Studies of Science, 38*(1), 7–33.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.

Wertsch, J. V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge: Harvard University Press.

Wilson, M. W. (2011). 'Training the eye': Formation of the geocoding subject. *Social & Cultural Geography, 12*, 04.

Yoon, S. A., Elinich, K., Wang, J., Steinmeier, C., & Tucker, S. (2012). Using augmented reality and knowledge-building scaffolds to improve learning in a science museum. *Computer-Supported Collaborative Learning, 7*, 519–541.

Zahn, C., Krauskopf, K., Hesse, F. W., & Pea, R. (2012). How to improve collaborative learning with video tools in the classroom? Social vs. cognitive guidance for student teams. *Computer-Supported Collaborative Learning, 7*, 259–284.