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Supporting Public-Facing Education for Youth: Spreading (Not Scaling) Ways to Learn Data Science With Mobile and Geospatial Technologies

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A project called Mobile City Science (MCS), a partnership between the University of Washington, New York Hall of Science, the Digital Youth Network, and two high schools, leverages young people's proclivity for on-the-move digital engagement to re-place and mobilize learning through public, community settings that youth identify as being relevant to their daily lives. At its most fundamental level, MCS teaches and engages young people in new forms of data science, especially around collecting and interpreting spatial, real-time, and dynamic data. This digital STEAM curriculum has more ambitious objectives. Ultimately, the research team hopes this work disrupts an absence of youth input in neighborhood and community development processes, using the power of spatial data and visualizations that young people create about their communities as a ticket for entry into ongoing policy and planning conversations. As youth will be the ones making critical decisions about these same communities in due time, it is prudent to apprentice them into valued forms of civic participation. Moreover, as long as youth ideas go unheard, leaders and adult community stakeholders have an incomplete picture — and are missing potentially transformative solutions — regarding current issues. This example of a digital STEAM curriculum for youth to engage in data science with mobile technologies provides ideas for teachers to make instruction more public-facing.

We are all familiar with that pedestrian moving along the street, head bent down, eyes fixed on a tiny smartphone screen. Many of us have been that pedestrian, coming up for air to avoid a collision with another person or a car. Across the globe, young people seem exceptionally wired for this ability to maintain a running text conversation while avoiding bodily harm from oncoming vehicles or signposts. Clearly, this interaction with mobile technology is not the sort that engenders a lot of community engagement.

Or is it? What if using a smartphone on the move was a conduit to historical queries about one's location? What if our mobile texts were part of an intergenerational conversation about the story behind a beloved community feature? What if being on the phone during a neighborhood stroll was a form of "place-conscious education" (Gruenewald & Smith, 2014)?

How might educators and education designers use this commonplace deportment of mobile tech use — no matter the location — to safely spark relevant, real-time community inquiry and data collection that leads to long-term civic investment on the part of youth? Based on how youth already use technologies, what are the design opportunities for *moving* teaching and learning out of classrooms and into school and home neighborhoods? How can using a smartphone on-the-move (Taylor & Hall, 2013) connect learners more intimately to the location through which they are traveling?

In our work on a project called Mobile City Science (MCS), a partnership between the University of Washington, New York Hall of Science, the Digital Youth Network, and two high schools, we leverage young people's proclivity for on-the-move digital engagement to *re*-place and mobilize learning through public, community settings that youth identify as being relevant to their daily lives. At its most fundamental level, MCS teaches and engages young people in new forms of data science (e.g., Berman et al., 2016; Loukides, 2010; Makar & Rubin, 2009; Philip, Olivares-Pasillas, & Rocha, 2016), especially around collecting and interpreting spatial, real-time, and dynamic data.

This digital STEAM (science, technology, engineering, arts, and mathematics) curriculum has more ambitious objectives, however. Ultimately, our researcher-educator team hopes this work disrupts the practice of limited youth input in neighborhood and community development processes, using the power of spatial data and visualizations that young people create about their communities (Enyedy & Mukhopadhyay, 2007; Polman & Hope, 2014; Radinsky, 2008; Rubel et al., 2016) as a ticket for entry into ongoing policy and planning conversations.

Because youth will be the ones making critical decisions about these same communities in due time, it is prudent to apprentice them into valued forms of civic participation. Moreover, as long as student ideas go unheard, leaders and adult community stakeholders have an incomplete picture — and are missing potentially transformative solutions — regarding current planning issues.

Framing Ideas

MSC is an exemplar of *an adaptable, public-facing curriculum* that

1. Builds upon youth's routine technology use;
2. Responds to exceptional community features that students and educators find important; and,

3. Supports classroom teachers and other educators to operationalize students' learning across settings.

Our use of *adaptable* rather than *adoptable* (Barab & Luehmann, 2003) is intentional. The curriculum values and highlights the particularities of different cities, communities, and neighborhoods (e.g., see Bouillion & Gomez, 2001). We are not scaling, but *spreading*, a common set of design principles that comprise this educational intervention (e.g., Cobb et al., 2003).

The aim of this paper, therefore, is to articulate an engineered, innovative learning ecology (e.g., Brown, 1992) and capture how it traveled and changed across three U.S. cities over 6 months, with three distinct teams of teachers and facilitators. Following is an overview of the design principles that bind our three-city intervention together. We also describe how the objectives of researchers, students, teachers, and organizations, in conjunction with the place-based affordances of each community, differed.

The flexible and locally contingent nature of the curriculum is a strength of the design (Kirshner & Polman, 2013). As such, classroom teachers and educators hoping to teach across schools and neighborhood spaces can adapt this design to explore questions that are of local relevance.

The Importance of Understanding and Using Spatial Data

With the advent of Geographic Information Systems (GIS) and spatial data infrastructures (SDI), spatial data is increasingly used as evidence for resource allocation and decision-making in community planning efforts. The *Next Generation Science Standards* (National Research Council, 2013) also recognize the importance of spatial visualization. Examples include the following:

- **Earth and Human Activity HS-ESS3-4:** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- **HS-ESS3-6**: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Compelling community stories and needs can be told via densities, distributions, spatial forms, and relationships. Not only professionals, but "grassroots data users" (Elwood, 2008) are a growing contingency of the various groups that make up the public that relies on spatial data to support their recommendations for change.

Young people should be included in, but are often left out of, diverse arrangements of grassroots data users in neighborhood planning processes (Taylor & Hall, 2013). Youth need to be able to track and understand spatial arguments (e.g., Phillips, 2013) to advocate for their own futures that will take place in some kind of community setting. How can public schools and their community partners prepare and actively engage high school students in informed community advocacy work?

In MSC, participating students are invited to think of themselves as researchers, documenting their communities with mobile technologies toward a culminating purpose of reimagining future development in that place (Gruenewald & Smith, 2014). Researcher-educators begin by posing a very broad, general design challenge that goes something like the followig: All neighborhoods and communities are changing, so how would you want to

guide that change? What do you already know and what do you need to know to participate in guiding that change?

The MCS curriculum is divided into three phases, all of which rely heavily on spatial data and developing young people's locative literacies, "place-based, digital modes of reading and writing different representational forms at the scale of the city" (Taylor, 2017, p. 534). Youth participants first engage in a series of activities to collect data around their community. They then do focused data analysis and finally build evidence-based arguments on how community spaces should be preserved or changed to be more conducive to youth learning and development. The designed activities through the community have a focus on the following:

- Geo-located documentation, including video, photos, and text annotation;
- Talking to various stakeholders in the community and collecting audio records of these conversations;
- Following and making new pathways (e.g., Ingold, 2016), some of which are historical and no longer visible or are nonhuman, recorded in the form of .gpx files; and
- Looking for juxtapositions and asking why these might exist (Wolfe, 2017).

Supported by teachers, explanations are usually found online by digging into open source maps and SDIs of greater neighborhood or city trends. The curriculum uses and continues to iterate on an arrangement of newer and forgotten technologies (Bang, Marin, Faber & Suzukovich, 2013; Stevens, 2000). These tools include GPS devices with still camera capabilities, open source GIS software, wearable cameras, a mobile mapping platform, paper, transparencies, paper maps, and pens. We refer to this bundle of older and newer technologies as an MCS Toolkit; every group of youth participants has the toolkit in a backpack for mobile exploration.

Based on ongoing feedback from participants, we are also designing potential and best uses of Mobile Augmented Reality (MAR; Ryokai & Agognino, 2013) to support live annotation of images and historical inquiry in the field. To date, our MAR designs build upon a mobile mapping platform called Siftr that was developed by the Field Day Lab at the University of Wisconsin (e.g., Holden, Gagnon, Litts, & Smith, 2014).

MAR platforms like Siftr have been used by both K-12 and university educators to re-place interdisciplinary investigations outside the classroom across diverse cultural, ecological, and neighborhood settings (i.e., Frandy, 2015; Mathews & Holden, 2012). Current MCS activities using MAR rely on mobile phones with enabled geolocation services and Google Cardboard.

Curricular Adaptation, Not Adoption, in Three Major US Cities

Within each of our cities the curriculum has been, and continues to be, implemented and revised. In Chicago, with the Digital Youth Network (DYN) and their partner high school, in New York with the New York Hall of Science (NYSCI) and their partner high school, and in Seattle with an undergraduate course at the University of Washington (UW), MCS takes shape around student interests and neighborhood assets. The curricular flexibility to specific locales contradicts the "disembedding" (Giddens, 1990) tendencies of scaling formal education across multiple places (cf., McKenney, 2017).

All of the neighborhoods in which the participating students lived and work have been historically underserved and are undergoing rapid changes, displacing people that have

been living and working in these communities for generations. As one example of such displacement, University of Washington undergraduates are collecting and analyzing data along the Duwamish River, Seattle's only river.

The Duwamish River was the source of food and livelihood for the Duwamish People, Seattle's First People (Thrush, 2007) and is now a designated Superfund site due to industrial runoff. Exhibits and docents at the Duwamish Longhouse and Cultural Center remind visitors that bodies and communities were nourished and sustained by this river. Today fishing from the Duwamish is prohibited due to poisonous levels of toxins found in marine life. From a viewing platform, UW students used their smartphones to document the profound industrial presence along the river in contrast to the serviceable (to human life) images of the river displayed at the Longhouse.

As a cross-city, cross-institution team, we are not scaling implementations. Instead our efforts are *spreading and adapting* to the specific programmatic objectives of each youth-serving organization and their school partners, as well as the local community features and what resonates with the daily lives of youth. Of course, we shared a common set of design principles outlined at the beginning of this article and also used a common set of data and analytic methods.

Had we not had this flexibility and mindset of adaptation rather than adoption, the curriculum would have failed as irrelevant to youth once it moved from Seattle to Chicago and then New York. While we expected and hoped to see consistent practices across sites, we also viewed local adaptations/differences as evidence of "the core intervention [being] flexible and responsive to varied contexts, local actors understand[ing] the relevant principles, and researcher-practitioner networks facilitat[ing] ingenuity, [and] critical reflection" (Kirshner & Polman, 2013, p. 2).

Programmatically, differing curricular adaptations and objectives guided locally relevant learning opportunities for both students and their educators. In Seattle, we used the curriculum to strengthen the connections between the university classroom and the immediate neighborhood and city in which the university is located (e.g., Knapp, 2014). Many of the courses in UW's Education, Communities, and Organization program are interrogating and contributing to the learning spaces and communities that are being threatened by urban development (Kinloch, 2007).

In Chicago, the Digital Youth Network and partner high school used MCS to increase the visibility of the secondary school in the neighborhood so that residents welcomed students. Students, in turn, were invested in sticking around not only after the school day but after graduation as well.

In New York, teachers and museum educators used the curriculum to help secondary students develop a deeper understanding of the community and its needs (e.g., Jackson & Bryson, 2018), and in so doing, strengthen connections between the New York Hall of Science and students in proximal schools. These distinct program adaptations suggest the fidelity and utility of MCS design principles across diverse social, cultural, and geographic settings as robust learning environments.

Adapting the MCS curriculum across settings productively constrained student technology use for investigations in local contexts, responded to place-based and historically relevant interests, and helped educators assist youth learning outside the classroom in community locations. Moreover, facilitating MCS required that teachers and other adult stakeholders at each site deepen their historical understanding of the local community and the

relationship their home institution(s) had to that location over time (Gruenewald, Koppelman, & Elam, 2007).

Across research sites, MCS teachers' and facilitators' relationships to places also intersected with their varied roles and responsibilities within their organizations. These shifting local teaching roles contributed to the ways MCS was adapted and spread. In Chicago, educators from DYN, in partnership with the classroom teacher, were responsible for implementing the curriculum, and a rotating team of DYN mentors visited students in their first period science class. In their larger DYN programming, this team of educators, many of whom have professional backgrounds in technology and the arts, acted as mentors or coaches in a variety of activities related to engaging youth in digital media, arts, and computer science (Baron, Gomez, Pinkard, & Martin, 2014).

In New York, NYSCI facilitators joined a health sciences teacher and the school principal to implement the curriculum. While the school principal and staff were available and invested in MCS Chicago, NYSCI educators had the hands-on, on-the-move assistance of more school personnel.

Finally, in the Seattle iteration of MCS, a team of higher education teachers – a professor and a graduate teaching assistant – and 10 graduate student mentors implemented MCS within the context of an undergraduate course in learning theory. Implementing MCS within this tiered structure of teaching and mentorship changed the learning and teaching experience. Smaller teams of educators and mentors had autonomy over what activities within MCS to use for accomplishing different learning objectives. Across these three research sites, a "tangle of teachers, strategies, and tactics" (Rust, 2017, p. 1) strategically reconfigured how mobile technology and on-the-move mapping were taken up by youth participants.

Public-Facing as a Curricular Standard

MCS draws upon the ideas of public pedagogy (e.g., Giroux, 2003), where teaching and learning "[become] an active and deliberate intervention in the public domain" (Biesta, 2012; p. 691). We are interested in different configurations of human togetherness that become possible outside of the classroom and how youth presence invigorates public space. By public-facing, we connote the following characteristics of the designed learning and teaching activities:

- Partner teachers and educators were trained to support student inquiry across classroom and neighborhood spaces;
- Young people were mobile through their communities in new ways rather than learning exclusively within classrooms;
- Participants were collaborating with one another and other (adult) stakeholders to identify neighborhood assets and issues;
- Students engaged in inquiry and data collection processes that were in real-time and elicited by place-specific observations.

Common Methods

Across the three adaptations, we shared a common set of data collection and analytic methods. As such, we amassed (generally) three symmetrical data corpi. We relied heavily on video data, both on-the-move and also in more stationary arrangements. Even though youth participants had wearable cameras (Taylor, Silvis, & Bell, 2018), researcher-educators also wore or carried cameras to document how sense-making was not only

distributed across people and the various communicative modes of the body (e.g., eye gaze, gestures, and body position), but also directly linked to aspects of the place. Capturing this kind of footage is not trivial, and a coauthor Silvis created a primer for team members new to the process of filming moving, collaborating groups of students.

In addition to video data, we collected digital stills, audio files, and map or .gpx files that youth produced. As we collected and received data, we created composite video files and content logging these files for interesting moments of learning and teaching (e.g., Jordan & Henderson, 1995) and followed the development of student ideas.

We conducted this ongoing analysis with an eye toward revising the curriculum for different settings, using open coding techniques and microanalysis of interactional hot spots. Our research team discussed these moments, taking notes and generating high-level interpretive themes of student and educator participation. We created a set of analytic memos (e.g., Saldaña, 2015) after each collective viewing session of video data. Looking across the analytic memos, we then developed more detailed themes that were specific to a site, or an implementation (i.e., certain themes were only important in one city), and themes that were prevalent throughout all implementations (Boyatzis, 1998).

We found four themes to be the most relevant for our questions about the affordances of newer and forgotten technologies to support public-facing educational designs. First, technologies did, in fact, help students see *cities as dynamic and changeable.* Second, digital and paper-based tools supported students to *excavate buried histories* of their communities. Third, drilling-down on the affordances of geovisualizations, the tools promoted youth *counter-mapping* with a public audience. And finally, usig mobile, handheld technologies mean that facilitators were *teaching-on-the-move* through community spaces.

Findings

This section provides some specific findings of how MCS used the affordances of older and forgotten technologies to support public-facingeducation designs for young people living in underserved or underrepresented urban areas. All lab or classroom work was informed by, or in preparation for, fieldwork in the neighborhood.

Cities as Dynamic and Changeable

As a first example, in New York students generated topics they wanted to explore within and throughout their Queens neighborhood, such as health, transportation, and recreational amenities. One data-gathering session in the community took place in a large public park that had been developed in the 1960s. This location offered students the chance to experience and document the dynamism of urban spaces.

Through their earlier research into the history of the community, they uncovered several instances in which unhealthy or unsafe buildings and areas had been transformed through community activism. The outdoor data gathering session provided a physical backdrop for a facilitated discussion on how the park had been transformed from an ash dump into the setting for the 1964 World's Fair.

Contemplating this transformation gave the students a chance to document some of the important assets this public park brings to the fabric of the neighborhood. Students and educators also discussed a nearby location that was the site of a skate park. This

recreational space was the result of a community development project spearheaded by local youth who lived in the area.

Students later walked to the Louis Armstrong Museum, where they saw firsthand how Mr. Armstrong not only improved his own property, but also took it upon himself to improve neighbors' properties as well. Students documented their discussions with wearable cameras and a GPS device, and relied on their previous historic research and paper maps to provide further documentation.

The discussion in the large public park was important for several reasons. First, it provided context to the idea that urban spaces are changing and can be highly engineered from previous forms. An educator first introduced this idea when he brought in copies of *Robert Moses: The Master Builder of New York City* (Christin & Balez, 2014) for students to read. This notion is not trivial and is often new to youth who have not lived long enough to see dramatic changes in their own neighborhood and city.

Second, the conversation highlighted that young people can effect change by organizing and advocating for something such as a skate park. Third, particular design features of the park, such as big plazas for meeting and for providing opportunities for a diverse population to gather, showed up in the recommendations that some students made in the culminating public charrette.

Excavating Buried Histories

Students also returned to a classroom to review and analyze work they had accomplished in the neighborhood. Educators structured these lab moments around geovisualizations of data collected in the community to identify spatial patterns, possible discrepancies between groups, trends, and the opportunity to go deeper into a question that emerged from being on location. Teachers and facilitators supported students to make connections between on-the-move experiences in the neighborhood to static data representations.

In an example from Seattle, a group of UW undergraduates returned from a walking audit of the University District and compared observations and artifacts they collected across five different locations (determined by the instructor). They were particularly interested in how their geotagged digital artifacts showed particular historical accounts of the neighborhood and erased others.

In their documentation of a mural funded by and hosted on the walls of a major national bank, students displayed frustration at the erasure of the First People of Seattle, the Duwamish, in the artistic rendering. University students wondered how their own mapping of the neighborhood, particularly in this instance, re-inscribed or re-presented some dominant narratives of the place while also giving voice to stories of development that have been made invisible for decades. This experience resulted in the students' recommendation that future classes visit former Duwamish longhouse communities.

Current versions of the course take groups of undergraduates to the banks of the Duwamish River and the Duwamish Cultural Longhouse to interrogate and compare different versions of Seattle's urban development. A facilitator is incorporating virtual reality using Google Cardboard in this iteration of original MCS activities, contributing yet another adaptation to the MCS toolkit that supports novel forms of data analysis and visualization.

Counter-Mapping

After classroom work, students returned to public forums to present their evidence-based recommendations. Usually these forums involved local educators, urban planners, clergy people, parents, and other youth from the neighborhood. We call these public events, "youth counter-mapping" (Taylor, 2013; Taylor & Hall, 2013), meaning they are relying on spatial data they have collected and analyzed, but also providing rich personal narratives of why and how this data is meaningful for their own lived experiences of being and learning in this place.

In New York, students built a comparative argument around Queens and Manhattan to illustrate resource discrepancies between the boroughs. They argued that, despite the greater racial and ethnic diversity in Queens as compared to Manhattan, there are no equivalent experiences or tours of the cultural assets for locals and tourists of Queens. There are dozens of such showcases in Manhattan (i.e., bus tours and walking tours), as they demonstrated via a map.

As a potential solution to this discrepancy, students designed a bus tour of Corona, Queens, that highlights the diversity of the area as well as the anchor cultural institutions that — from their youth perspective — make the area exceptional. The young women included many stops that they did not know about previous to their participation in MCS, including the Louis Armstrong House and Museum. They also included places they frequent in their daily lives, such as religious institutions and other museums. One group member commented on how she saw her role in this work: "We're doing the research, we're going to be growing up and living in this area, so we want our city to see the way…. We want our city to grow up the way we want." As a form of real time assessment, audience members questioned various features of the bus tour, and students responded to these critiques as though they were, in fact, the experts.

Teaching on the Move

In on-the-move activities, students were not alone in moving through the city to imagine and design possibilities in public spaces. Teachers accompanied youth and assisted in structuring how mobile activities were facilitated and experienced. In this way, teaching was also on the move and presented opportunities for adapting MCS on the fly.

As is true for teaching with technology in classroom settings, MCS educators spent hours engaged in professional development and curriculum planning so that geolocative technological tools and supports for mobile activities were responsive to places (as recommended by Kerr, 2016). However, unlike technology-supported classroom learning, being out in the city created opportunities for emergent place-based inquiry that sometimes required pedagogical improvisation. For example, in Queens, during a student-led walking audit of neighborhood health clinics, students wondered why clinics were closed on weekends when local residents were potentially off work and in need of medical services. While standing near a busy intersection, a student suggested they use Google to search for additional information about the clinic and identify the business and its clientele (it specialized in Chinese medicine and featured Mandarin signage in the windows and on the awning).

After searching for the clinic on a student's device, a facilitator used his own mobile phone to gather more details. The group compared what they learned from their online search to on-the-ground evidence before them. Here, as in other moments of emergent curriculum

adaptation, teaching-on-the-move required that educators capably and literally think and act on their feet.

Conclusions

Public-facing educational designs and research put students at the nexus of neighborhood networks that consist of their schools, youth-serving organizations, community centers, and adult residents and stakeholders. This teaching and learning configuration fundamentally reorganizes community networks, as youth have traditionally been ignored or spoken about, or siloed in classrooms too often segregated by age, race, and economics. Educational designs like MCS help young people become stewards who build and sustain community relations as they finish their high school careers and potentially move into various roles as engaged community members.

As everyday technologies become increasingly mobile, locative, and ubiquitous, educators should consider the potential of these technologies for engaging students in the world around them, rather than banning mobile devices from teaching and learning (e.g., Kalir, 2016). What could be more relevant to the lives of young people than digital culture coupled with their physical community? Alongside youth, the time has come for education designers to think creatively about *re*-placing and mobilizing learning with digital media toward civic, public-facing objectives.

Returning to the idea of spread not scale, students had their own objectives for doing this work, too; researchers and teachers within youth-serving organizations were not the only ones with objectives for implementing MCS. In Seattle, undergraduates were motivated by uncovering and resuscitating buried histories of land development to promote more equitable and relevant place-based education initiatives.

In Chicago, youth wanted to use their work as community researchers to promote greater job opportunities for teenagers in areas immediately surrounding the school. In New York, youth were invested in using their data to advocate for equitable health, transportation, and cultural amenities that were present in other boroughs and neighborhoods across the city. These motivations emerged as participants grew more comfortable with their role as youth advocates, but also as they learned more about their community through the designed activities.

Looking forward, researchers from this team and teachers and educators from organizations beyond this network are in the process of codesigning public-facing learning experiences with students in nonmetropolitan areas, and from other geographically, racially, and economically diverse backgrounds. Different students living in different places continue to elicit shifts in the original inception of MCS. However, the core design principles – building upon youth's routine technology use, responding to exceptional community features that young people and educators find important, and supporting classroom teachers and other educators to operationalize students learning across settings – remain intact. We look forward to studying how teachers support their students to do this work and exploring what new meanings young people make of their role as informed and active student-citizens, even with device in hand.

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