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Preliminary Testing of a Peer-Teaching Model Using Geospatial Open Source Tools to Address Community Health Issues

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ABSTRACT: Young people's involvement in community-based research is a well-established interventional model, but not nearly as widespread as it should be. Although young people have valuable insights to share, their voices are often missing from the research process. To address this void, Youth Enrichment Services (YES) engages youth from under-resourced contexts and creates authentic learning experiences by connecting them to social issues that impact their lives. YES' most recent project is highlighted in this study, where teenage youth of color examined the social and environmental conditions that contributed to heightened lead exposure in a Pittsburgh Community. Using community-based participation research, students became the study's architects, data gatherers, and analysts thereby centering their critical perspectives in an adult-centric research regime. This study offers insight into how the employed peer-teaching, field-based learning model equipped students to facilitate their own geospatial learning to address toxic lead exposure. The results suggest that by harnessing and then channeling the varied interest and technical skill levels of students, peer-teaching models significantly enhanced technical learning outcomes when implemented in an applied, community-oriented research context. Integrating technical skills education with youth driven CBPR adds the critical dimension of youth experience into the research process and allows students to own their knowledge development.

INTRODUCTION

Pittsburgh, like many cities along the Rust Belt, experienced rapid job loss and decline in the late 20th century as deindustrialization impacted the city's primary economic resource: steel. Pittsburgh has undergone significant economic revitalization over the last three decades through its shift into education, technology, and medicine, however, neighborhoods primarily made up of Black and low-income residents continue to experience the consequences of persistent systematic racism (Trotter and Day, 2010).

As the city transformed into an epicenter for innovation, many of Pittsburgh's Universities have employed traditional academic research frameworks in which field experts enter predominately Black neighborhoods in order to collect data. This data often bypasses neighborhood residents and fails to be integrated in the landscape of the neighborhood once the analysis has been completed. Even more rare is the inclusion of young people in the research process.

In an effort to disrupt this existing research framework, in 2017, Youth Enrichment Services sought to create a research project that was entirely driven, carried out, and presented by young people. Through a peer-based teaching model, young Pittsburgh residents learned mapping software skills in order to examine lead exposure in their own communities.

Youth Involvement in Community Research. Community-based participatory research, CBPR, aims to involve community members in research occurring in their own neighborhoods. Often residents have unique place-based experiences and engage in practices that create unique knowledge about a community (Akom et al., 2016). CBPR empowers community members to act as the driving force at every stage of a research project, from data collection to dissemination. Traditional academic experts collaborate with community members to ensure power is distributed equitably throughout the process. Including community members in research about the given community increases the likelihood that conclusions drawn from the research will be integrated into both the daily lives of community members

and their actions to enact change (Powers and Tiffany, 2006; Akom et al., 2016; Ravi et al., 2018).

In many forms of social research youth become subjects and are rarely included in other stages of the research process. This is especially true for youth from marginalized communities as their voices are often dismissed when they speak up about issues affecting their lives and communities (Akom et al., 2016; Kohfeldt et al., 2016). Recent trends have begun to involve youth in the research process through forms of quantitative data collection and analysis (Langhout and Thomas, 2010; Jacquez et al., 2013). A majority of these projects focus on issues related to health and health promotion.

Involving young people in research about their communities is beneficial to both the young people themselves and the research produced. Studies have proven that allowing young people to voice their perspectives empowers them and furthers their social and emotional development through engaging in critical thinking and problem solving skills (Delgado, 2006; Powers and Tiffany, 2006; Bozlak and Kelley, 2009; Weisz and Black, 2009; Wong et al., 2010). Research that includes youth voices ensures those most affected by the issues being researched will place value on the results and find them accessible. Similarly, studies have shown having youth serve as peer educators within the research process yields similarly, mutually beneficial results (Wong et al., 2010; Marvell et al., 2013; Ravi et al., 2018). Young people feel empowered by serving in such a role and the research is more likely to result in meaningful data as young people often feel more comfortable speaking with their peers than an adult figure (Shiner, 1999). Peer educators have been utilized in a variety of settings including small groups, one-on-one sessions, and counseling environments to recruit and disseminate information.

Additional research has looked into innovative ways to educate young people on STEM subjects (Flicker et al, 2008; van Wart and Parikh, 2013; Smith et al., 2014; Erdogana and Stuessy, 2016; Krajcik and Delen 2016; Krajcik and Delen, 2017b). However, little research has looked into combining these STEM teaching methods with a peer-teaching model. Allowing young people to have a role in quantitative data collection using STEM skills is a method that has rarely been utilized in both academic research and traditional classroom settings yet has the potential to yield valuable results for both the research itself and young participants.

Organization Background. Youth Enrichment Services, YES, is a non-profit organization located in Pittsburgh's East Liberty neighborhood primarily serving socially and economically disadvantaged youth ages 14-21. Through student-driven mentorship, YES aims to provide professional, personal and leadership development through various programming opportunities. In all of their programs YES prioritizes an evidence-based approach to youth mentorship and enrichment. Additionally, in previous programming YES has intentionally incorporated program participants as co-developers of various initiatives in order to highlight the strengths of each young participant.

Its summer programming, organized through a Pittsburgh-wide initiative known as Learn and Earn, connects young people to enriching early work experiences that build skills and expose young people to future opportunities for employment and education. Within this framework, YES collaborated with the Allegheny County Health Department, West Virginia University, and the University of Pittsburgh in 2017 to create an opportunity for young people to engage in a research project surrounding lead exposure in Pittsburgh. Leading the Discussion on Lead aimed to involve YES participants in the entire research process while using a peer-based teaching model to teach technological skills involved in mapping software.

PROGRAM DESCRIPTION

Participants. Program participants were recruited from the larger group of young people involved in the YES portion of Pittsburgh's summer Learn and Earn program. Upon applying for employment through YES, youth attended an opportunity fair where they determined their summer placement preferences. Leading the Discussion on Lead was included in this opportunity fair and all youth who listed the program as their top choice were accepted and placed, respectively.

Many young people involved in YES programming often have to undergo work-learning trade-offs, particularly during the summer, that many of their higher-resourced counterparts do not. As a result, participants are compensated through financial stipends. Leading the Discussion on Lead participants were able to earn a stipend of up to $1100.

A total of six young people participated in the project. Through the Learn and Earn program participants' parents and/or guardians were notified of the project and provided the appropriate permission for the young person to participate. To protect the identities of the participants, their names have not been included. All six participants were youth of color and a majority were entering their junior or senior year of high school. Four youth participants lived in Lincoln-Lemington, the neighborhood in which the research was occurring, or surrounding neighborhoods. Many of the neighborhoods in which participants reside have historically been under-resourced and are composed of majority Black and low-income residents. Five of the six participants attended a Pittsburgh Public High School, with three attending Westinghouse High School in Pittsburgh's Homewood neighborhood, a school with a zero percent passing rate on State science exams.

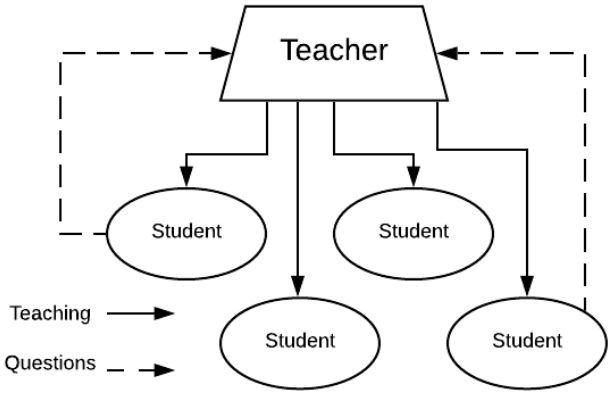

Figure 1. Teacher-centric education model.

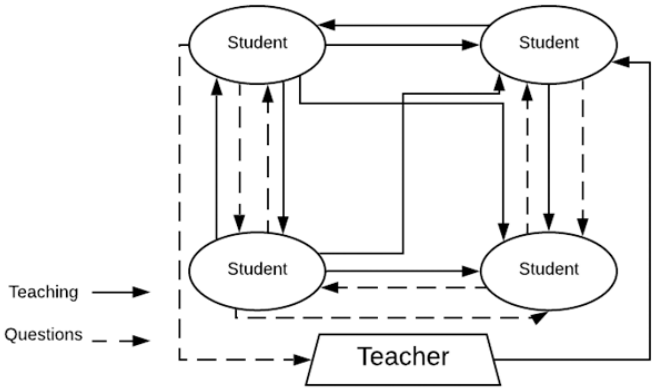

Figure 2. Peer teaching model.

Program Structure. In traditional STEM education endeavors, the teacher is the source of a majority of skill-focused tutorials. Figure 1 illustrates how channels for questions and assistance almost always return to the teacher in such a model. This traditional model often leads to student disengagement with the material because the teacher is addressing the entire group rather than differentiated needs of individual students. Additionally, students sometimes feel uncomfortable asking the teacher for assistance for fear of being judged. This discomfort combined with an inability for the teacher to meet every student's needs results in disjointed and often incomplete learning experiences (Ravi et al., 2018).

Maintaining student engagement is a particularly pertinent challenge of summer programing as many young people are voluntarily participating. A peer-driven teaching model works to have the students themselves act as teachers of the subject and engages them at every point in both the teaching and learning process (Bozlak and Kelley, 2009; Ravi et al., 2018). Youth serve as micro-experts for a particular domain and subsequently teach this information and skill to their peers. Teachers serve as connectors between young people and facilitate more complex issues when they arise. As illustrated in Figure 2, this model allows information to flow much more between peers rather than between a large group of young people and their teacher. This increases the comfort and engagement young people have with the material because they are learning from one another rather than an adult figure.

As previously stated, little research has been done into combining STEM education with a peer-based teaching model. Existing research that employs such a model has shown a number of benefits including increased engagement with the subject matter. Students also gain interpersonal and leadership skills through their role as a teacher and learner. Additionally, having young people act as educators for their peers empowers them to feel confident about their knowledge and abilities.

From July to August 2017 participants engaged in roughly 40 hours of research as they acquired the knowledge and skills necessary to carry out every step in their research process. The first portion of the program involved rapid exposure to each aspect of their project in order for participants to select a domain they would like to become "micro-experts" in. The first lessons of the program utilized a traditional teacher-centric model as a facilitator conducted trainings with the full group of participants. Figure 3 outlines one of the lessons from this portion of the process.

In order to implement a successful peer-based teaching model within a short time frame, program facilitators created core concepts from which to structure programming time. These concepts allowed participants to be the driving force

Wednesday July 6 – 4 hours	Mapping conceptual framework • *What is actually happening when we make a flat map of a large, curved surface?* • *When does my knowledge of how maps are made enter into my data visualizing that I might do day-to-day as a GIS professional?*	1. Students will be able to (SWBAT) model how a spherical surface is projected onto a flat one. 2. SWBAT describe how projections algorithms influence how a map "looks" and map these variances onto actual perceptions of the world. 3. SWBAT interpret geospatial meta data and tinker with its parameters in both CartoDB and QGIS	Using blow-up globes and overhead projector film, we'll make two global maps using two different projection algorithms and discuss the tradeoffs in this fundamentally imperfect process.

Figure 3. Sample lesson plan.

for the project while also ensuring youth engagement would effectively complete necessary tasks.

Doing Over Watching. As opposed to traditional conceptual learning that often occurs when new topics and skills are introduced, participants were tasked with utilizing new skills from the beginning of their learning processes. The facilitator engaged participants in activities throughout the entirety of each lesson in order to sustain interest and engagement. Participants were challenged to complete tasks as they acquired the necessary skills in order to develop problem solving and critical thinking skills.

Micro-Experts. Upon completion of the first half of the program participants selected an area they would become micro-experts in. They were responsible for teaching additional information about their domain and providing assistance to their peers when necessary. This allowed for participants to select portions of the project they were interested in, thus furthering the commitment they had to the subject matter. For example, one participant gained a fair level of competency in digitizing features onto a map layer, a key skill in GIS mapping. When a situation arose where another participant was struggling with this particular skill, the facilitator was able to connect the two participants to engage in the peer-based teaching model. Peer-teaching created a learning environment in which peers could assist one another within both their micro-domains and in general using varying styles and at different rates.

Youth Control Everything. In working with technological software for the first time, many participants faced challenges in the process of completing their given tasks. If peers could not assist to solve the issue the facilitator would then step in to explain a solution as the participant maintained control over their computer and associated software. Engagement was maintained because the facilitator did not take control over the computer in order to quickly solve the issue but rather walked the participants through each step. The amount of control given to participants also meant one young person was assigned the peer leader role. The facilitator would look to their participant when full-group decisions or activities had to be carried out in order to continue the peer-based learning model.

The peer-based teaching model places young people at the center of both the teaching and learning process. Within the Leading the Discussion on Lead framework in particular is carried out through individualized teaching methods from peer to peer. In Figure 4, a specific activity from the lesson plan discussed in Figure 3 is outlined to show how participants were able to facilitate the learning process amongst each other. The peer-teaching framework was utilized in this context to ensure participants were engaged throughout

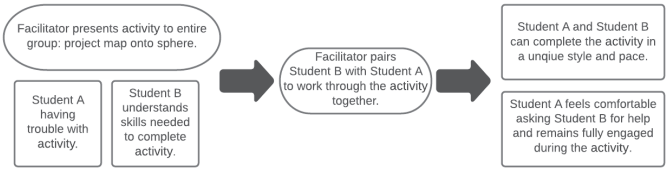

Figure 4. Leading the discussion on Lead Program Model example.

the entirety of the research process. Through unique teaching styles and learning rates participants were able to work directly with their peers to gain new knowledge and skills rather than learning from an adult facilitator in a large group setting.

RESULTS

Increased Awareness and Tangible Skills. Program participants successfully completed all aspects of the research process in order to produce accessible results to share with their communities. Through three community events participants were able to present their completed maps, shown in Figures 5-7, and demonstrate the knowledge and skills they acquired related to the topic of lead exposure in their communities, GIS mapping, and the research process. Additionally, participants and facilitators engaged in post-program interviews and surveys to gauge the impact of the peer-based teaching model and the overall project.

The increased awareness of lead exposure coupled with gaining skills in mapping software allowed participants to create final products that were of reputable quality and added substantive value to the ongoing efforts in the community. The resulting maps used existing and youth-collected data to measure a variety of factors related to lead exposure including the age of housing stock in the community, concentrations of children in public spaces, and the number of children in the community against versus the number of parks.

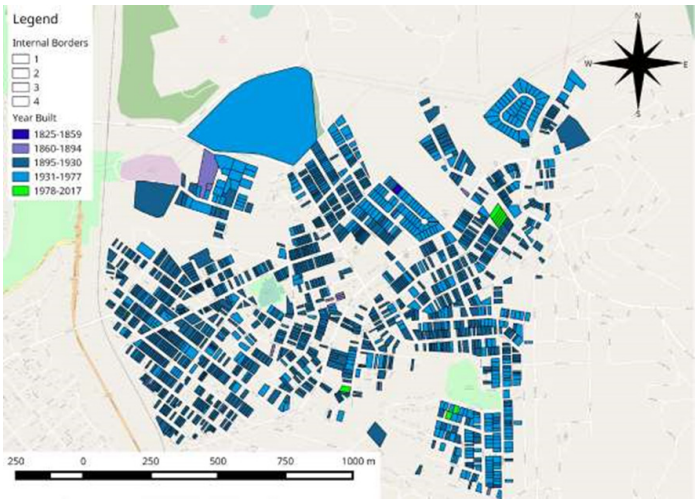

Figure 5. Final Product – Age of housing stock in Lincoln-Lemington.

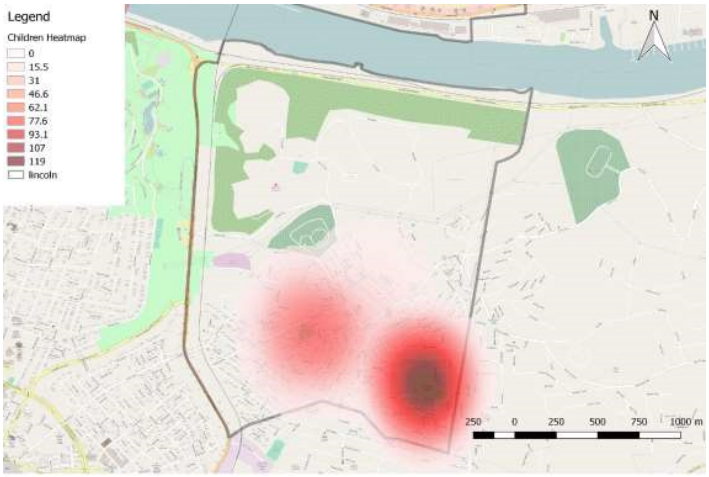

Figure 6. Final Product – "Heat Map" of children's high concentration in public spaces.

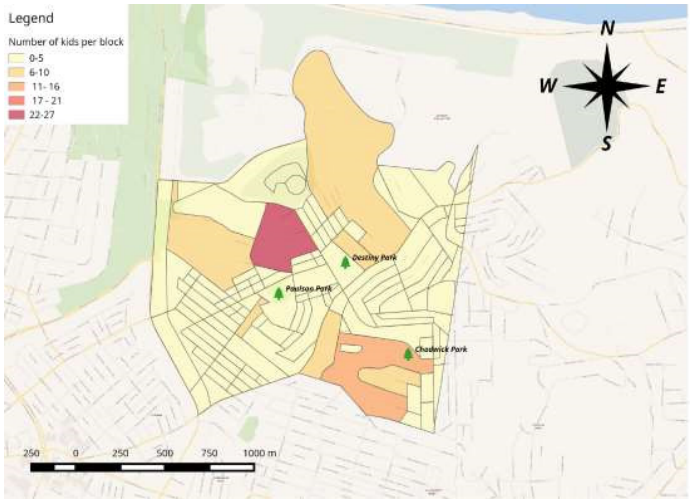

Figure 7. Final Product – Count of children by census block with park points overlay.

Figures 5-7 illustrate the quality of the map's participants created.

Four participants discussed having limited knowledge of the extent of lead exposure in their communities. In a post-program interview one participant stated, "I knew about some of the dangers of lead, but not really in depth". Through the project participants gained an awareness of the extent and impact of lead exposure in their own communities. This increased awareness can be understood through one participant's post-program interview response, "there's babies being born, and there's parents who don't even have the resources to help their children out in our community. Especially in poor communities." Empowering young people to be involved in the entirety of the research process allows for them to be exposed to issues and skills previously unknown to them. It further allows for them to facilitate the learning process for others in their peer groups and communities.

In addition to an increased awareness of lead exposure in their communities, participants also gained introductory-level skills for both the research process and GIS mapping. Through the fast-paced and peer-teaching-focused model, participants quickly grasped many of the basic skills associated with conducting research and using mapping software. Some of these basic skills included:

- Determining appropriate variables
- Creating a layer attribute table in mapping software
- Digitizing data collected in the field
- Using existing data from databases
- Understanding file extensions
- Importing and exporting data across various software platforms
- Map symbology
- Digitizing map features
- Creating work process logs
- Importance of troubleshooting

The peer-teaching model allowed for participants to be exposed to both issues in their community and new STEM skills through a unique learning style that best suite each participant. When participants were tasked with teaching one another the necessary skills the young people were able to create individualized lessons that kept one another engaged.

All participants reported increased knowledge of lead exposure and mapping skills after completing their project. Students surveyed reported that participation in the project led them to think about future career choices and also increased their professional contacts. Combining these results with the increased knowledge in STEM and research participants are better equipped to pursue new academic and overall opportunities.

Aided in Social Development. Beyond the tangible skills participants acquired, their time in the program allowed them to gain experiences and skills beneficial to their social development. As previously mentioned, researchers have shown the benefits associated with providing young people with spaces in which their voices hold value. Illustrated in Figure 8, a majority of participants reported feeling their opinion mattered and possessed decision-making power. Participants continually felt empowered through the lessons and tasks of the project they and, as a result, felt a greater sense of ownership, pride, and commitment to their research.

Additionally, participants felt challenged throughout the project which aided in critical thinking and problem-solving skills development, as seen in Figure 8. Finally, Figure 8 also indicates increased development of interpersonal skills as participants worked together on project tasks. Combining the tangible STEM and research skills participants acquired with the associated feelings of empowerment created an environment where young people were eager to continue mak-

Participants asked to rate the below statements on the following scale: **Strongly Agree, Agree, Disagree, Strongly Disagree, No Opinion** N=6		
"I feel like my opinion mattered." Strongly Agree – 1 Agree – 4 Strongly Disagree – 1	**"Staff challenged me to do my best."** Strongly Agree – 3 Agree – 3	**"I am better able to work with others now."** Strongly Agree – 3 Agree – 3
"I was encouraged to learn new skills at my job." Strongly Agree – 4 Agree – 2	**"I was allowed to lead an activity."** Strongly Agree – 4 Agree – 1 No Opinion – 1	**"I helped make decisions at my job."** Strongly Agree – 3 Agree – 2 Strongly Disagree - 1

Figure 8. Post-program participant survey.

ing an impact on their communities.

Success in Peer-Teaching Model. The skills learned and empowerment felt by participants was made possible by the peer-teaching model employed. Based on responses during post-program interviews, the model enhanced the technical learning experience because participants felt more comfortable learning and asking for assistance from their peers rather than an adult facilitator. Additionally, utilizing small-group learning allowed for participants to acquire skills at varying rates and styles. Both the facilitator and peers were able to differentiate teaching methods based on each participant. This allowed for a majority of participants to strongly agree with the notion that they learned new skills while participating, as indicated by survey results in Figure 8.

Similarly to the value of the program overall, participants who engaged in peer-teaching also reported feeling more engagement, ownership, and empowerment as a result of their work. Figure 8 shows that as many as half of participants strongly felt that they had leadership and decision-making opportunities because of their position as teachers for their peers. Placing young people in leadership positions communicates to them that their voice has value in a space and, in turn, results in increased confidence in their abilities and complete necessary work. In the case of this program many participants expressed a desire to spend additional time on the project. A majority of participants stated that they felt their work was meaningful and had the chance to help their community. The ownership participants had over the entirety of the project also resulted in a desire to continue identifying and solving issues in their community in order to enact change.

RECOMMENDATIONS

Leading the Discussion on Lead was completed within a short time frame, roughly one and a half months. Those looking to implement similar models for STEM education and academic research should increase the allotted time for such a program. Much of the subject matter was covered quickly and students were often not given the necessary time to master each skill as desired. Additional time would allow for further development of peer-teaching skills and result in deeper social skill development.

The primary purpose of Leading the Discussion on Lead was to provide young people in Pittsburgh with STEM education they otherwise were not being exposed to through innovative peer-teaching methods. Program results illustrate the benefits such a program has, particularly on youth of color, in both STEM knowledge and social development skills. This style of teaching STEM content should be implemented in traditional school settings in order to increase student engagement with the subject matter and allow for further student development through peer-based teaching rather than traditional teaching frameworks.

Finally, CBPR requires individuals and other entities who have immense knowledge about their communities to actively participant in the research process. Youth do present unique, and often unheard, perspectives on their communities yet it would be beneficial to combine youth perspectives with the knowledge older residents and community organizations possess. Collaborating with community health clinics, religious groups, political offices, and other community groups would further the impact the results of such a project could have on the community.

CONCLUSION

Engaging community residents, specifically young people, in the research process is mutually beneficial as it increases the value and accessibility of the conclusions drawn from this research for community members and positively impacts young people's social development. As evidenced in previous relevant literature as well as the preliminary findings from this current project, when youth feel empowered by the people and environment around them it increases the likelihood that they will be interested and engaged in not only the current project being completed but future opportunities to enact change in their communities.

Leading the Discussion on Lead successfully employed a peer-teaching model to increase the proficiency and knowledge young people in Pittsburgh possessed in STEM skills and the academic research process. The model allowed for participants to gain mapping software skills previously unfamiliar to them as well as the additional skills necessary to engage in every step of the research process because participants served as active teachers of challenging skills. Combining STEM education with the inclusion of youth in CBPR resulted in valuable data of lead exposure in Pittsburgh as well as beneficial interpersonal skills that will positively impact participants in each of their future endeavors.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

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ABBREVIATIONS

CBPR: Community-Based Participatory Research; YES: Youth Enrichment Services

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