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‘Socially Distanced Community Engagement’ –Teaching GIS Site-Analysis during COVID

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Socially Distanced Community Engagement: Teaching GIS Site-Analysis during COVID

Abstract

In the era of COVID, project-based classes that incorporate community engagement (i.e., interacting with both a physical site and members of the community) as part of their learning approach, have taken a significant blow. When connecting with people becomes an unhealthy practice, how can site-based learning remain embedded in engineering teaching and practice while accommodating virtual education instruction? Within civil and environmental engineering (CEE), GIS mapping has allowed students to step outside the classroom and engage with site-based work while focusing on spatial learning technologies. The open-ended processes of spatial data gathering can be used to draw students into community observation, inviting a focus on ecological and social interactions of infrastructure, site, community, and equity. However, in the era of COVID, the full range of site-based learning processes, including community engagement, are impossible to implement.

This paper describes two amended processes for site-based learning through GIS data practices during the post-COVID shutdown period. Pre-COVID versions of the exercises asked student teams to explore a single site by observing and mapping infrastructure. This involved documenting community use of space and interacting with the local community to obtain multi-layered data on social equity, economic, and physical aspects of the site. However, two primary changes were made: in one class students were asked to explore their own local environment rather than travel to a shared site of focus. In the other, student teams collected only visual site-data foregoing the community engagement component. These students then connected electronically with community partners to gather social data.

The study draws on data from student participation in two different classes: a large introductory class and a smaller advanced class. Data includes a qualitative analysis of exit interviews with a sub-set of both undergraduate and graduate student participants. This paper examines to what extent the site-based practices retain value given the limits imposed by social distancing, and whether these workarounds reveal unexpected strategies which might be applicable to future remote learning, and to community-based learning even when physical reconnection is allowed.

Introduction

Critical of traditional textbook-focused teaching strategies, universities are exploring ways to prepare engineering students to develop more open-ended problem-solving skills. [1]. Building on the ideas of learning through practice [2], engineering programs are developing alternative models for teaching and learning, in which creative exploration, and broader human-centered aspects are introduced as early stages of the research process, preceding the definition and resolution of the typical engineering problem set [3], [4]. Drawn from models of professional training in medicine, and touted as a student-centered learning strategy, project-based, or problem-based learning (PBL) has become a popular model to integrate specific challenges of professional engineering into the learning process by incorporating the complexities of human and site-based work into engineering curriculum [5], [6]. While pointing out the overly-broad range of instructional methods justified under this title, critics agree that the active and collaborative processes have value for student learning in engineering [7], [8], [5].

For civil and environmental engineers, whose work is often connected to construction, land, and water issues on specific sites, and whose work heavily affects communities, community-based PBL process has increased learning value. While engineering students understand the importance their work serves for communities, they are often poorly prepared to engage with a community or to work collaboratively within specific social and spatial contexts. The site-connected, open-ended, and self-directed experiences of PBL provide an opportunity to introduce creativity, social responsibility, and social justice into the classroom context [9]–[11]. However, for faculty, PBL can difficult to implement, manage, and assess. A challenging structure to fit within the strictures of the engineering curriculum [12], [13], moreover, the open-ended thinking PBL sets out to support is often in conflict with the solution-driven conceptual structure of engineering coursework. The two can be difficult to integrate into a single course context [14].

One strategy for the integration of PBL into the civil and environmental engineering context can be through its integration with data-science coursework using Geographic Information Systems (GIS). Visual and spatial thinking, such as sketching and drawing, are frequently referenced as valuable teaching process for open-ended thinking [15]–[18]. Bringing together such spatial exploration with geographic and site-based investigation, GIS provides an opportunity for engineering students to interact with the site, integrate a community-focused lens, and leverage spatially-based thinking, all the while developing skills in new technology [19]–[23].

This study focuses on aspects of two courses taught in the Department of Civil and Environmental Engineering at SMU in fall 2020. Previous versions of these courses had students engage with site and place through gathering social-spatial data, and observing physical-ecological aspects of infrastructure alongside the impacts of such features on community, livability, and equity. This coursework explicitly integrated GIS with site-focused research and data collection and provided open-ended PBL within a community-based research opportunity.

In 2020, however, these ambitions were impacted by the hybrid and virtual learning restrictions, and social-distancing limits imposed by COVID. The necessity to reimagine methods of site and community connection provided an unexpected opportunity to study these strategies. The outcomes observed reveal both expected learning losses within the rich social and site interactions that had been intended, but also unexpected value found in the workaround processes created. Such values may be integrated into improved strategies for community-based spatial learning practices.

COVID has exacerbated economic and academic inequities across the United States [24]. Although many communities are impacted, communities of color and those affected by poverty are disproportionately so [25]. More than ever, the aspects of PBL that allow student-engineers to intersect their work with real-world problems and to focus on the social aspects of engineering problem-solving, are of heightened importance. Therefore, a strategy that not only allowed but uncovered new PBL strategies through GIS, and which was able to impact site-based student learning, can be argued to be of increased value for those student-engineers grappling with a COVID limited, and post-COVID learning environment.

Research

With the sudden onset of the global pandemic in March 2020, most institutions of higher education worldwide, and particularly those in the United States, made a swift transition to online or virtual learning instruction. The following academic year (2020-21), many university classes were held in virtual and hybrid formats, or mixed in-person and online learning. Universities struggled to balance the conflicting priorities of health risks of in-person learning, with the inherent limits in learning value.

Much has been written on student learning losses during COVID, and on the lessons learned from ways in which institutions of higher education responded to the virtual learning situation, such as a *National Academies Proceedings* [26] and a special issue of *Studies in Higher Education,* [27]. In the context of engineering education, there has been much discussion in the literature on the ways that COVID limits forced overdue focus on the possibilities of strengthening learning strategies in virtual classroom instruction, as well as improving the emotional support required for remote student experiences [28]–[30].

However, a further teaching and learning challenge was opened by the transition to virtual learning for courses which were specifically focused on breaking down the traditional distance between community, site, and the student-engineer. Virtual or hybrid learning systems derailed not only the practice of community-engaged coursework, but the underlying intentions of the coursework itself. Moreover, given the isolated nature of much of these students' learning week, it was arguably these COVID-era engineering students for whom a contextualized learning process would have been most valuable.

Arguably, one straightforward way in which some courses were able to retain a connection to site was, indeed, through the integration of GIS within the engineering learning content. Specific and location-based, all GIS studies obviously take place on an actual site in the real-world. And as a software-based technology that is increasingly cloud-based, COVID era learning and collaboration could easily be reimagined through this online structure. A series of panel discussions took place which focused on this aspect of resilience in geographic information science education [31].

However, in the case of the two SMU CEE case-study classes, pre-COVID, the GIS portion of the coursework had been designed not only to allow students to situate their work in a real geographic setting, but more specifically, to integrate processes of GPS-linked site-data collection. Environmental and social data would be collected through real interaction with site and community. Pedagogical ambitions included teaching students (1) to gather specific qualitative and quantitative aspects of site infrastructure and community interactions and (2) to observe and question the way these observations impacted site-design, access, safety, health, livability, and equity. Thus, both courses required some degree of active site interaction from students. The limitations of social-distancing due to COVID, therefore, strongly impacted these learning processes in spite of the cloud-based nature of GIS.

A range of workarounds were developed, altered across the varied nature of students' learning situations. Some worked individually and others worked in virtual teams. Most of those who worked individually were asked to physically investigate sites close to their individual learning context, be that at home, due to virtual learning, or on-campus, due to hybrid-learning options. Some virtual teams actually interacted in person, participating in-person in socially-distanced team visits to a physical outdoor site. Those members who couldn't join collaborating through different kinds of virtual interaction. Others had a mix of individual visits to the site, either with in-person or virtual interaction, followed by online collaboration, and finally some had one local student gather all physical site-data for the team.

First, we wanted to find out what range of challenges students reported facing in these community or site-based analysis processes. Were there specific challenges common to many of the variations of workaround settings? How did students describe not only physical data collection difficulties but challenges faced due to the socially distanced and hybrid processes of the work? Secondly, what were the outcomes of these challenges? In addition to failures, could we observe solutions or specific strategies developed to overcome the challenges of their virtual learning processes, particularly given the scattered nature of their site-based perspectives? Finally, after studying student outcomes, we wondered whether any aspects of these solutions might be transferable. Innovations developed might be of value for the ongoing hybrid nature of higher education, and for such virtual and in-person learning process that may emerge post-pandemic.

Research Methods

There are two guiding research questions in this study:

- *RQ1: What challenges did students face in their virtual, community-based site analysis?*
- *RQ2: What strategies did students use to overcome the challenges of the isolated or scattered nature of their virtual, community-site analysis?*

Building up a rigorous qualitative research methodology, we use a comparative cohort analysis and more specifically a multi-case analysis process [31] in which we investigate community-based site analysis conducted during the pandemic as a 'quintain' (i.e., activity or phenomena) that has impacts across two different course-contexts. We use cross-case analysis as a method for mobilizing knowledge about community-based site analysis [32]. Specifically, our methodology draws on the theory of learning articulated by Donmoyer (1990) [33] which views learning from cases as a mean-making exercise that allows researchers/learners to access the experience of others, extend their own personal experience, produce new knowledge, and augment existing knowledge and experience [32]. Both expected and unexpected outcomes are revealed by comparing and contrasting qualitative evidence of learning insights to generate themes and patterns discussed in the data analysis section.

Participants

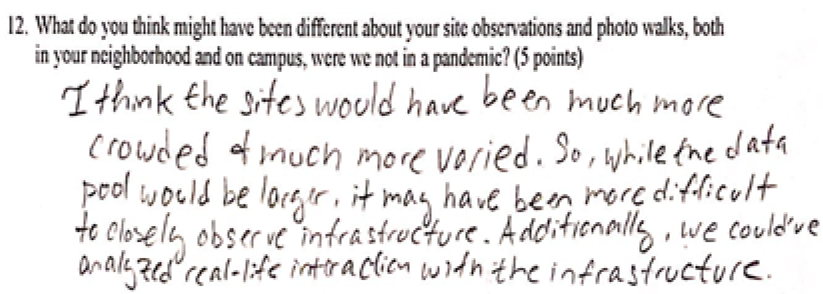
For this study, data from two classes of University level engineering students were combined for a total of 31 student participants. This cluster sample was convenient, formed of SMU students attending a GIS-focused segment within a required undergraduate introductory class for potential civil and environmental engineering majors, and a graduate class focused on GIS as a tool for research in engineering. Non-participation in the study was due to students missing classes or incomplete work, or student selection at consent. All students, regardless of consent, participated in the workshops as part of their coursework. The undergraduate 'Introduction to Civil and Environmental Engineering' (Intro to CEE) class had 25 students, of whom 22 participated in the study. The graduate 'Geospatial Mapping' (GIS) class had 16 students, of whom two did not complete the class, and 9 participated in the study.

Due to COVID limits, all the graduates and many of the undergraduates were fully virtual in their classes. All students were limited in their potential physical site-access. Furthermore, faculty were fully cognizant of the risks of requiring any sort of physical or social community engagement from students. Nonetheless, the intention was that all students would be introduced to site-based data collection and explore the physical and perceptual specifics of that site, as a strategy to access socially relevant and creative learning outcomes. [21], [34]. This ambition led to a variety of alternative engagement methods for students during their site studies.

Data Collection

The undergraduate class was focused on introducing students to the major sub-disciplines of civil and environmental engineering and developing their analytical and critical thinking skills. New to this class was the inclusion of a course-long group project focused on engagement with site and place through observation and collection of data related to different types of civil infrastructure (i.e., roads, sidewalks, buildings, streetlights, etc.). However, opportunities for full engagement with site and place were limited by the impacts of COVID. Engagement and contact with local community members while out on site was discouraged. In addition, the hybrid nature of fall 2021 instruction created an environment where students were geographically dispersed, creating both a challenge and opportunity to engage with multiple different sites: sites that students were very familiar with (i.e., their home neighborhoods or on-campus) and sites that they were less familiar with both on-campus and off-campus.

In the undergraduate class, data was collected through reflection questions embedded in the course final exam. First, students were asked to reflect on what they believed would have been different about their site observations and data collection efforts had we not experienced the effects of the COVID pandemic *(see Figure 1)*. Second, students were asked to imagine that during their site visits, they might have had the chance to interview local stakeholders about their experience with civil infrastructure in their communities, whom would they have interviewed. While for virtual students their study-site was their home neighborhood, even those living on campus were limited to campus-adjacent environs. Therefore, students were asked to reflect on the home-neighborhood opportunity which had unexpectedly been created by the socially-distant environment of COVID, which led them to act as both a "community member and an engineer" in their examination of place. Student written responses were accepted as paragraphs or bulleted narrative with no word limit imposed.


12. What do you think might have been different about your site observations and photo walks, both in your neighborhood and on campus, were we not in a pandemic? (5 points)

I think the sites would have been much more crowded & much more varied. So, while the data pool would be larger, it may have been more difficult to closely observe infrastructure. Additionally, we could've analyzed real-life interaction with the infrastructure.

Fig. 1 Example of undergraduate student written response.

The graduate class, held fully virtual, was focused on the integration of creative research methods with the teaching of geospatial GIS technical tools. Past iterations of the course had undertaken a collaborative and intensely focused study of one particular local site and neighborhood, in which the integration of community and stakeholder engagement was built into the spatial learning process. Due to the disparate physical locations of the student body during

COVID, this new version of the course was altered to be much more varied in spatial focus. To maximize engagement potential, a variety of site collaboration options were developed. Some students worked in mixed physical and virtual teams on two sites near the University. Sites were chosen both for local accessibility and for faculty familiarity with specific community connections, human contacts which could be made available through online networks. Other more geographically distant student teams worked in pairs, in nearby neighborhoods chosen for specific student connections to their own neighborhoods. And one team worked internationally, where one student was physically situated and two others were culturally connected but virtual.

Primary data for the study was based on post-class interviews in which students were asked a series of questions not only about their data collection and community-engagement processes, but on how the limits of COVID and imposed social distancing had affected such processes, and of their perceptions of both positive and negative learning outcomes based on that altered intervention process. Interviews were recorded, transcribed, and coded to allow a series of themes to emerge from the data [35].

Data Analysis

Data from both groups of students' responses were analyzed for evidence of learning-insights gained from students' hybrid and virtual community site-analysis experiences. Thematic analysis was used due to its ability to allow focus on qualitative insights from a range of different student observation types, its flexibility in allowing the emergence of unexpected outcomes or insights from the data, and its structure which enables organization and collection of key features as patterns that emerge from the data.

The study followed the thematic analysis framework proposed by Braun and Clarke (2006) [35] consisting of steps in which researchers: (i) familiarize themselves with the full range of data, (ii) generate initial codes, (iii) search, (iv) review (v) and then define emergent themes from the data and (vi) extract representative themes for final analysis in relation to the research questions.

Primary issues that came into focus through both undergraduate and graduate responses were centered around the difficulties that each student encountered due to virtual learning limits, and insights into new approaches and opportunities that they uncovered through that experience.

Findings

RQ1: What challenges did students face in their virtual, community-based site analysis?

Three main themes were identified as student challenges during virtual, community-based site analysis (*Table 1*). Students expressed difficulty in exploring and understanding the site location due to the disconnect they found between their interactions in multiple contexts- individual community and the physical space. When analyzing responses, such interactions were grouped into seven subthemes identified as barriers students observed in their data collection process.

Table 1 Students' challenges in virtual, community-based site analysis

Main theme	*Subtheme*
A. Reliance on others for physical site data	Difference between personal social site experience versus reliance on interaction through social media (Yelp, Google Reviews)
	Difficult to interpret teammate's firsthand experience of visit
	Wanted to gather data not available online as public data
B. Physical interaction	Neighbors and community leaders identified as valuable information sources, but challenged by lack of informal and personal interaction with these community stakeholders
	Different physical connections to place altered experience of project; remote students forced to depend on teammates for context
C. Impact on community of practice	Lack of personal connection to local site made it harder to conduct site analysis
	Virtual communication felt impersonal; lack of in-person and interpersonal collaboration impacted quality of work and analysis

A. Reliance on others for physical site data

Many students described data sets they were interested in collecting but were unable to access due to COVID restrictions. For some, this restriction was a lack of access physical data such as sidewalk quality or accessibility, a granular-level observation typically collected in-person.

To generate site observations some students envisioned a site experience based on online imagery or descriptions. Several described frustrations with such data as dependent or inhibited due to lack of firsthand physical exploration. Others described difficulties in making accurate interpretations of the physical site when they were limited to a secondhand view, whether from online sources or from teammates' who had visited in-person.

> *"I had to personally do my photo-walk virtually via Google Earth. This was tougher in that I was constrained to the date and time the photos were taken …Some sites were still under construction and I was unable to do night photos or research myself."*

Limitation in data available online combined with an inability to interact with the site prompted students to feel a potential loss of work quality. Despite leveraging tools to understand the spatial and social dimensions of the site, students were left sense of having an incomplete understanding of place.

> *"I wasn't there in person so I couldn't see, like I couldn't just go…with my own eyes. Like how this community looks and how it's affected …I wasn't fully there and that's kind of a*

necessity…But I still was able to see, you know, Google Photos, the pics that [omitted name] took and look up stats and what not online, but definitely would be easier to be there in person."

B. Connection of community and site

Constrained physical interactions with the location during site analysis influenced the relationship between the students and the community observed. Even those students who could visit the site firsthand were limited to minimal interaction with the community, or found that the site itself was altered due to the absence of the community. (*see Figure 2*). Despite wanting input from community members, physical distancing restrictions limited social data collection to that which could be collected online. Interactions with community members were conducted in a more formal dialogue through surveys, email, and organized online meetings, or searches within existing social platforms and online reviews. These methods of communication contributed to a less personal interaction with the stakeholders. Although many students viewed their neighbors or the community as valuable information sources, the lack of informal, personal interaction contributed to students' feeling less connected and invested in the site analysis.

Fig. 2 Example of student observation of the lack of people in what is usually 'public space' and its impact on site understanding.

"I guess the most difficult part is, [in] this sort of collecting the data, [is] that you need interaction with actual stakeholders of the community to be able to establish meaningful data.

C. Student experience of community of practice

Students reported establishing regular routines to communicate via virtual calls or messaging with their own team members and with community stakeholders. Even so, students expressed that the lack of face-to-face interaction contributed to difficulties in forming interpersonal connections within their community of practice. In the case of student-student interaction, this created feelings of decreased quality of work in contrast to in-person site collaboration.

"I was still able to meet with my team members once, by wearing masks and social distancing. We also met a lot over zoom… and I think I would have received a higher quality of education being able to do everything in person."

Some students who were dual stakeholders, participating as both a community member and researcher in their site analysis, felt personally connected to their project site. Despite reported disconnects in team interactions, several dual stakeholder students reported feeling greater investment with the site analysis due to their resident status in the site they were analyzing.

> *"It put me in a different position to observe areas that I am familiar with. With this different perspective [as a dual stakeholder], I had the chance to analyze possible problems with infrastructure and thus possible solutions."*

RQ2: What strategies did students use to overcome the challenges of the isolated or scattered nature of their virtual, community-site analysis?

Three main themes were identified as student strategies used to overcome challenges faced during virtual, community-based site analysis (*Table 2*). Students described workarounds they found to interact with and better understand their site. Although workarounds in GIS leverage existing tools or technologies, student responses described creative solutions to their site-analysis challenges that may not have been derived under typical community engagement conditions.

Table 2 Students' strategies to overcome challenges in virtual site analysis

Main theme	*Subtheme*
A. Unintended methods for data collection	Data extraction from virtual stakeholder conversations (email, Zoom) and methodology of noting then verifying
	Team photo repository of site led to questions on interpretation; challenged in-person visitors on their analysis of the space
	Reliance on satellite imagery and social media provided perspectives of site that may not have been considered with ground-visits
B. New methods for data processing	Manipulating open data to extrapolate/infer other data not available online
	Greater use of specific digital technologies for data visualization due to limitations and more critical collaborative dialogue on site space
C. Interpersonal social insights	Regular meetings impacted productivity and timing, but less inter-personal team connection
	Became aware of the hitherto undervalued importance of casual conversation in building relationships with community and within teams

A. Unintended methods for data collection

As interaction with community stakeholders was confined to e-mails or virtual calls, students described unexpectedly uncovering site characteristics during offhand communication not primarily intended for data collection. By extracting site characteristics from messages, then verifying these assumptions with stakeholders, students discovered an alternative way to better connect with and understand the stakeholders' site perspectives.

> *"[Rather than] recreating the wheel and trying to assess the community need…we took already what was already available and integrated it…."*

By relying on online resources students reported gaining new perspectives on the site which may not have occurred if in-person site observations were available. Although firsthand explorations of site were deemed important to students, satellite imagery and social media reviews also proved to be useful tools in understanding the site in unexpected ways.

> *"For me, using Google Earth actually helped because I was able to get angles on the site I wouldn't have in an in-person visit, and I don't think I would have thought to use Google Earth the way that I did if I had physical access to the site."*

Reliance on others for site interpretations also positioned students to pose questions to those who did access the physical site space. Since students were dependent on team photo repositories for both recent and personal accounts of the site, this challenged students to engage in critical team dialogue impacting collective site understanding.

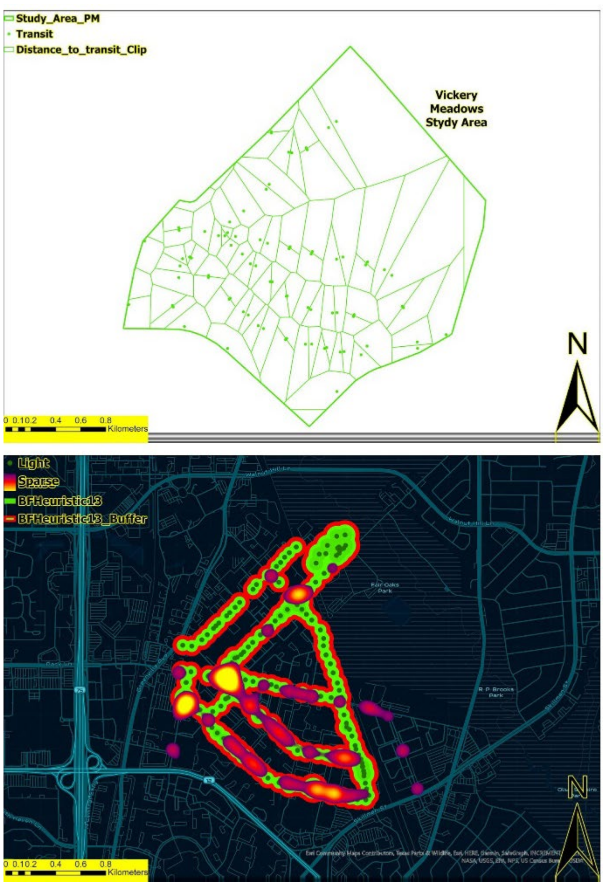


Fig. 3 New methods of hybrid site-data analysis

B. New methods for data processing

New strategies in data processing for GIS were recorded by graduate student participants. Students described navigating ways to display limited site data by developing alternative spatial strategies to better visualize the nature of the space.

> *"I really wanted to express the quality of the infrastructure in the area through a heat map and I didn't know that it's doable…it wasn't my initial idea for the GIS project but with the limited [data] I was able to find on this location…drawing the sidewalks into GIS got me into expressing the infrastructure quality."*

Since incomplete site data was available online, students used GIS tools to manipulate available online data to infer physical characteristics about the site. For example, (see *Figure 3*), some students identified street lamp locations by discerning the shadows of light-posts in online aerial photos, geolocated each lamp and then used light-area models to visualize the lighting of the site at different times of the day. Online impervious-surfaces data was used to map the sidewalks and then rank them by walkability based on lighting. Voronoi polygon analysis was then overlaid to describe the full accessibility of transit stops.

C. Interpersonal social insights

The problematic dynamics between scattered data collection and physically-distanced communication surprisingly allowed students to uncover insights about their communication skills, and how they work as a team. Despite regular virtual check-ins, a number of students reported missing the personal connection formed between teammates.

> *"I think I have taken space for granted previously when doing site analysis."*

Students reflected on the understated importance of building relationships through in-person conversations at the site, which were absent in their current processes. Such missing conversations between the team and community stakeholders were described as opportunities for not only data collection but to build meaningful relationships which would bring a greater depth of understanding to the site analysis.

Discussion

Amongst the impacts of the global COVID pandemic on post-secondary education, are its effects on instructional time, access, and content [36]. At the onset of the pandemic, many campuses sent residential students home, pivoting to remote learning. By fall 2020, some remained remote, some returned to instruction learning on campus while others, like SMU, pursed a hybrid instruction strategy [37]. These shifts in instructional approach have been found to create disparities in the student experience, and both opportunities and challenges in the manner as well as the content of instruction. Broadly identified challenges with e-learning are accessibility, affordability, flexibility, learning pedagogy, life-long learning and educational policy [38]. It has been found that available pedagogy used for face-to-face learning are not ideal for online learning. Though e-learning tools played a crucial role during the pandemic, questions still remain about the impacts of these shifts on specific education outcomes, and on how the shift will continue to impact educational outcomes [39].

To investigate issues related to community-based site investigations as a pedagogical approach, this research uses a multi-case analysis to reveal both expected and unexpected impacts of the limitations placed on this traditionally in-person activity. Findings revealed a cautionary tale about challenges related to site-based investigations in a hybrid instructional environment, as well as creative approaches to overcoming these challenges through the innovative use of GIS as both a tool for virtual site-knowing, and a tactic to encourage socially-distanced local site interaction. Students experienced accessibility challenges [38] due to the lack of physical direct interaction with community and team members, compared to that previously afforded by a site-based in-person instructional approach. These findings support earlier work which described specific challenges or obstacles faced by teams due to a shift to online teamwork during COVID, including team member performance issues created by the hybrid environment [40]. Our findings related to the community of practice also reinforced earlier findings by Wildman et al. (2020) [40] that uncovered changes in communication quality and quantity. Also revealed were challenges related to geographic differences in location, based on different student quarantine locations, which impacted the physical and temporal context of the team [40] including the ability to form interpersonal relationships, but also disparities in access to site data and understanding of the site.

The role of open data and open solutions to facilitate COVID research during the pandemic has been reported by the United Nations Educational, Scientific, and Cultural Organization and the Organization of Economic Co-operation and Development [41]. Our research reveals the critical role of open-source data and online analysis using GIS as strategies for overcoming barriers to much of the site-based research during the pandemic. Both classes demonstrated flexibility [38] in their approach to gaining access to site data. Students leveraged spatial and social tools (e.g., satellite imagery and Facebook) to understand the site, engaging in creative methods of data processing, manipulation and extrapolation to uncover data which may not have been revealed in traditional site visits alone.

Limitations and Future Work

This research was conducted early in the pandemic (fall 2020) when 'pandemic' instructional practices were new for both teachers and students. Were this study to have been repeated later in the pandemic, results may have been different. Further the hybrid nature of instruction and remote location of many students, and illness itself, made collection of students' observations and outcomes challenging and, in many instances, incomplete. Variations in student background including socio-demographic background and year in degree program, while broadening context and generalizability, may also have impacted results. Finally, results would be likely change with larger class sizes or if data was collected over a longer period as opposed to the brief period (i.e., 1-sememster) over which data was collected.

Future work can investigate the impact of continued use of new 'strategies' once physical contact and on-site access returns after the pandemic. Conversely future research could also investigate the ongoing use of several of these strategies as aspects of learning introduced by the pandemic wear on (i.e. ongoing virtual and/or hybrid learning). Another line of research may look into additional strategies which might help bridge the gap between physical site visits and the availability of online tools and resources. Finally, it would be valuable to study the impact of the limits on different types of student and in the study of different communities, to see how economic and academic inequalities might be further revealed or supported by these processes.

Conclusion

Developing a spatial understanding of place and site is a complex, multi-layered process. Many student-engineers struggle to do so even within a traditional in-person learning context. A complete site understanding involves the integration of physical site information: water, soil, infrastructure, and topographic data, along with quantitative social data: population, income, race and land use; as well as the more ephemeral qualitative data, such as sensations of safety, ease of passage, belonging, comfort, and community connection. GIS mapping has been shown to be a powerful tool to support students in the layered phases of this observation and documentation process. However, the confidence with which student-engineers learn to build a complete a vision of site remains dependent on the connections and interactions they make during site visits and community-engaged learning process.

The sudden restrictions in social and community connection altered the practice of these learning approaches. In this study, data from two engineering classes were collected in a multi-case analysis to uncover student insights about participation in socially-distanced but none-the-less community-based site analysis projects. Limits impacted both the assignments given and the student learning processes. Students were challenged to find alternative strategies to learn about, and document multiple aspects of site and community.

Student feedback reveals a range of perspectives on their connection to place with many admitting to experiencing an incomplete or scattered understanding of the site. Responses confirmed a sense of isolation even within the attempt to discover site connection. However, this study uncovered a variety of student workarounds with implications for continued use of such hybrid virtual/physical community-based site analysis.

Hybrid site-study had the advantage of breaking down some limits of distance. It allowed students access to sites and collaboration beyond their immediate geography and in some cases even across time-zones. Such long-distance access is both realistic and valuable in an increasingly global work environment. Conversely, for some who selected to work within their immediate lock-down neighborhood, the opportunity to investigate sites of familiarity created greater motivation for the overall work.

Students developed reliance on a broader set of data sources than previously: including photos, satellite imagery, and social media (e.g., Yelp or Zillow). Increased emphasis on the virtual experience was also found push students to make greater use of previously available digital tools (e.g., ArcGIS online), with the caveat that students reported an overdependence on secondary sources. Furthermore, students also reported putting more effort into developing good data-filters, or engineering judgement, and increased data interpretation skills.

The virtual experience revealed the need for greater trust both between team members and through virtual connections. Students described challenges in forming personal connections with local community but also reported the development of new communication skills through 'formal' or written email communication. This prompted gains in confidence in making and requesting critical team member observations. Finally, students reported an increased focus on team coordination and meetings, and the need for increased team-planning, and add-on effect of the wide-ranging and scattered quality of the data collection process.

First, this study reinforced the importance of interacting with a site in-person. GIS science is indeed resilient to online learning environments, however, the learning outcomes sought by integrating site-based research processes using GIS/GPS data collection cannot easily be replaced by virtual interactions. This includes the exposure to community and the design-value found in intuitive and qualitative understandings of site. Modifications made to these courses were not able to replicate the learning outcomes of the in-person versions of the courses.

However multiple new skills and workarounds were developed. This allowed aspects of hybrid site-collaboration, which is of increasing value as engineering practices move towards hybrid methods of site-study and collaboration. While new aspects of digital data-gathering, data judgement, collaboration, communication, and coordination described above can be argued to be of great value for student learning, the primary lesson learnt may be in flexibility. In every engineering community situation, neither fully collaborative, fully integrated nor fully virtual processes may be available, cost-effective, or ideal. The value of an intention and the effort to find some aspect of real engagement, and then the skills to adapt available tools to fill alternative processes may be the most vital learning outcome from this study. While ongoing challenges in accessibility are expected if virtual community-based site analysis persists, flexibility in change will remain an integral engineering tool in community-site engagement processes.

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