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AUGMENTED REALITY AS A TOOL FOR INDUSTRIAL HERITAGE EDUCATION AND INTERPRETATIONS

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AUGMENTED REALITY AS A TOOL FOR INDUSTRIAL HERITAGE EDUCATION AND INTERPRETATIONS

By

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List of Abbreviations

- KeTT: Keweenaw Time Traveler
- NPS: National Park Service
- KNHP: Keweenaw National Historic Park
- GIS: Geographical Information Systems
- HGIS: Historical Geographical Information Systems
- HSDI: Historical Spatial Data Infrastructure
- CCHSDI: Copper Country Historical Spatial Data Infrastructure
- CLIR: Council on Library and Information Resources
- AR: Augmented Reality
- VR: Virtual Reality
- HUD: Head(s) Up Display
- QR Codes: Quick Response Codes
- SSO: Single Sign On

Abstract

Combining Augmented Reality with spatially and temporally robust Historical Spatial Data Infrastructures may have the potential to provide users with interpretive and educational opportunities they otherwise would not have. Adapting research oriented historical GIS projects such as the Copper Country Historical Spatial Data Infrastructure to usage as interpretive material through the utilization of “off the shelf” augmented reality applications such as AuGeo has the potential to expand the utility and reach of that research data outside of the lab, while providing new interpretive opportunities by allowing users to see that data in its original spatial context and giving them the freedom to explore it in their own way.

1 Introduction

Interpreting the past has always come with as many caveats and pitfalls as it has triumphs; records are left incomplete, landscapes lose their most valuable features to time and neglect, lived experiences go undocumented. Industrial heritage in particular feels these and other pressures; with landscapes yielding to redevelopment or requiring remediation, populations dispersing after industrial activity ceases, while the communities that remain are often plagued by economic and social instability. Fortunately, heritage interpreters have developed tools and techniques to tackle these challenges. Local museums/heritage groups work to maintain connections to the past through developing interpretive information such as placards, pamphlets, leading walking tours, conducting re-enactments, etc. Those heritage organizations maintain the responsibility of distributing that interpretive material throughout the landscape to account for things like missing structures or historical context. Maps have long been used as interpretive tools, providing visitors and users with graphical representations of the spaces they are interpreting. Maps have additional utility when layered together from different time periods, interpretive institutions use layered map exhibits to show the changes to the built environment of a site over time, producing graphical representations of larger segments of the past.

Others have already begun to explore the utility of Augmented Reality as another interpretive and educational tool on the belt of heritage professionals by

allowing users to explore heritage sites through the lenses of their smartphones where interpretive material is otherwise unavailable (Cushing & Cowan 2017, Kaplan & Shiff 2017, LeMire 2018, Davies 2014, Ellenberger 2017). However, few studies have been concerned with the intersection between Historical Geographic Information Systems/Historical Spatial Data Infrastructures (HGIS/HSDI) and AR, leaving a natural gap for this study to attempt to fill while simultaneously attempting to address the needs of local heritage professionals of the Painesdale Mine and Shaft Inc at the Champion Mine in Painesdale Michigan. This study used to attempts to fill that gap by asking how can the integration of Augmented Reality technologies with Historical Spatial Data Infrastructures support industrial heritage interpretation and education?

1.1 Case Study: Champion Mine

The “Champion Mine” largely refers to the Number 4 shaft house site in Painesdale Michigan, originally constructed in 1902 it is largely known for being the oldest still standing shaft house in the “Copper Country”. Major surviving structures at the site include the shaft house, the hoist house, the mine Captain’s office, and one of what would have been many oil houses. Beyond the grounds

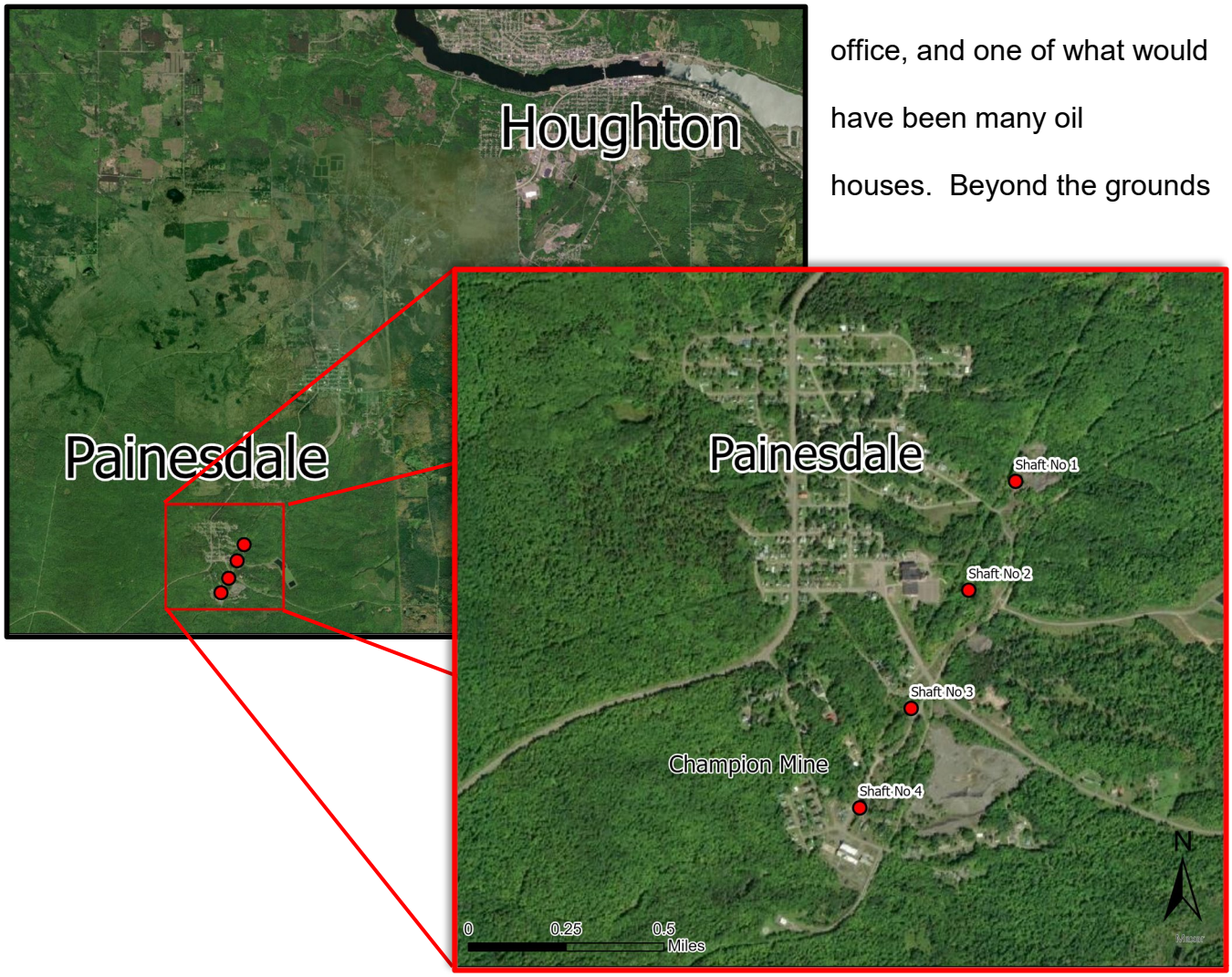

Figure 1: Champion Mine is located in Painesdale Michigan roughly 8 miles South West of Michigan Technological University

owned by the Painesdale Mine and Shaft corporation are repurposed machinist shops and housing formerly devoted to company employees. While the surviving shaft house was constructed in 1902, the Champion Mine itself was established

in 1889, and consisted of 4 shafts running at intervals from Atlantic Mine to Painesdale. As a result, the site itself represents only a small fraction of what would have been a part of the industrial landscape while in operation. The Copper Range Company operated the mines until 1967, through various trials and tribulations such as two world wars, and worker strikes. Painesdale Mine and Shaft Inc. has become more active in recent years, coordinating volunteer work events and digitizing the site's vast records collection. However, they operate under very limited resources, the majority of which go towards stabilizing and maintaining the site. To date, Painesdale Mine and Shaft Inc maintains a small amount of interpretive paneling and provides weekly guided tours of the site, with plans to develop more interpretive materials through collaborative efforts with students at Michigan Technological University to accommodate visitors outside of their relatively narrow availability.

Continuing this trend through the development of an Augmented Reality heritage application is a perfect opportunity to not only continue to evaluate AR as tool, but to nurture the collaborative relationships that are so important in this field. The Number 4 shaft house represents an important example of the Copper Country's surviving mining and industrial sites, which are rapidly becoming major attractions for heritage tourism. This situation presents an opportunity for heritage researchers within academia to collaborate with local heritage organizations to develop interpretive materials and programs for those sites to better support their communities.

1.2 The Intersection of Heritage and Historical GIS

In 2015, Lafreniere, led an interdisciplinary team including this author, to further expanded on the concept now known as a “Historical Spatial Data Infrastructure". The idea was to create a regionalized “space-time linked digital archive” capable of answering questions posed about the development of systems, geographic scale, accessibility and expandability (Trepal, Lafreniere & Gilliland 2020). This project has come to be called the Copper Country Historical Spatial Data Infrastructure or CC-HSDI, as its extent covers the major population centers of the Keweenaw Peninsula from roughly 1880-1950, a period chosen for its significance in the rise, peak, and decline of the area’s mining activity. The term “Copper Country” has come to colloquially represent most of Michigan’s Upper Peninsula’s Keweenaw Peninsula. The area’s unique geography led to unusual deposits of pure copper, some single pieces weighing multiple tons. The unusual nature of the copper deposits being mined coupled with the intense period of industrialization led to the nickname for the area.

The CC-HSDI contains hundreds of thousands of spatialized records from Polk city directories and the US census, digitized Sanborn Fire Insurance Plans providing highly detailed representations of the built environment, geographically linked school attendance records and business directories, as well as hundreds of “Stories" submitted by users of the CC-HSDI’s public interface known as the Keweenaw Time Traveler (KeTT). In the coming year, the CC-HSDI will also incorporate the full set of employee records from the Calumet and Hecla Mining

Company and the mapped full count decennial census. As the public interface, KeTT is often marketed as a sort of “Google Maps” for the Keweenaw’s history, however the approach is more akin to “deep mapping” (Ridge, Lafreniere & Nesbit 2013). Meaning, it provides access to a robust temporal depth of information not readily available on something like Google Maps. These differences are key because all those interlinked and overlaid data sources are what starts to give users the ability to develop their own deeper interpretations of the postindustrial landscape of the Keweenaw. The historical spatial data present within the CC-HSDI represents more than just some arbitrary representation of the past. These datasets come from primary sources and documents that served their communities for years, whether it’s employee cards marked with decades of service to mining companies or Sanborn Fire Insurance Plans updated with hand-written notes and annotations indicating new construction or buildings lost to fire, all of these sources work together as true pieces of industrial heritage together. While none of these sources are perfect on their own and have their own drawbacks, biases, and gaps, they are an essential step in truly trying to represent the past.

On the more scholarly side, the CC-HSDI has already been utilized in a number of research projects and dissertations, studies have been conducted on public schools as vectors for disease transmission (Lafreniere et al 2021), accumulated industrial pollutants and their potential impacts on children’s health (Stone et al 2019), public participatory GIS (Lafreniere et al 2019), industrial and

public archaeology (Trepal, Lafreniere & Stone 2021; Trepal, Lafreniere & Gilliland 2020; Trepal, Scarlett & Lafreniere 2019), historical education (Scarlett et. al 2019), and 3D procedural modelling of landscape change over time (Arnold & Lafreniere 2018). Future research is planned in studying the migration experience of French Canadians and their associated socio-economic mobility while they occupied the Keweenaw. Overall in-and-out migration patterns for the region during the periods of rapid industrialization and deindustrialization; potentially identifying trends in where miners came from, where they went, and what they did after copper mining. All in the effort of connecting the lived experiences in the Keweenaw to the greater narrative of the industrial Midwest.

Even with this body of scholarly work attributed to the CC-HSDI, the Keweenaw Time Traveler is not perfect. One of the longest acknowledged drawbacks of KeTT in its current iteration is that it's built for desktop browsers and does not support geolocation services within its proprietary interface. This presents a significant roadblock to attempting to use KeTT in the field, preventing users from establishing a real sense of place especially if they aren't familiar enough with the area to know where they are on the map. In fact, in the past when tours have been given using data from the CC-HSDI, a separate interface with geolocation has been used and mocked up to represent the future planned "mobile" version of KeTT (Scarlett et al 2019). The lack of true on-site interaction with these data sources in the field leaves a significant gap in the capabilities of the Time Traveler and by extension the CC-HSDI. The availability of this data

infrastructure and current limitations of the methods to interact with it create the perfect space in which to develop a mobile application using geolocation functionality. This is supported by the fact that mobile devices are already the dominant way in which people interact with Augmented Reality applications, making a mobile application the perfect way to augment the potential for interpretations developed by visitors to sites such as the Keweenaw National Historic Park (KNHP).

1.3 The Potential for Augmented Reality to Improve HSDIs

Using Augmented Reality (AR) applications as a platform to harness the power of a historical spatial data infrastructure can help to open the door to new experiences and opportunities for heritage interpreters and visitors to explore the complexities of industrial landscapes while complementing the limitations of things like curated walking tours. Cushing and Cowan identified the need to provide data from primarily research institutions such as museums, archives and libraries to non-researchers to allow them develop their own uses and interpretations with that data (Cushing & Cowan, 2017). They developed an AR walking tour as an attempt to address this shortfall called Walk1916. The application used spatially distributed photographs and narratives, sourced from local research institutions, to recreate some of the historical context of the 1916 Easter Rising, largely associated with the beginning of the Irish independence movement (Cushing & Cowan, 2017). Users were presented with a map

showing the locations the photographs represented, and directed to walk towards them as they saw fit, where they would be presented with a viewfinder to overlay the photos onto their device's camera, attempting to place the users in the same location where the photographs were taken. This approach demonstrated the potential for utilizing these kinds of resources outside of the institutions that house them, users commented on the positive effect of being able to contrast the historical images with their modern spatial context (Cushing & Cowan, 2017). Cushing and Cowan's results highlight the need to provide institutional research data to non-researchers, to support a broader interpretation of heritage landscapes by democratizing data broadly to permit unexpected new applications for that data. This report outlines an attempt to demonstrate the utility of the CC-HSDI combined with Augmented reality in supporting heritage education and interpretation efforts at the Champion mine site and encouraging the democratization of that same research data for heritage interpretation. With particular interest in addressing known shortfalls of establishing a sense of place that the CC-HSDI currently suffers from. The question is, how the integration of augmented reality technologies with the spatio-temporally robust Historical Spatial Data Infrastructures can support industrial heritage interpretation and education?

2 Literature Review

In order to establish the academic framework from which this study is derived, there are three main areas of literature that need to be considered; Digital Tools for Heritage, Historical Geographic Information Systems (HGIS), and Augmented Reality (AR). Many areas of digital heritage applicable to this report found early progress in the 1990s largely in digitizing existing archival collections at the university level (Stephenson 1999, Besser 1997). Collaborative efforts to provide online access to digital surrogates of cultural heritage materials can be found beginning in 1995, the Museum Educational Site Licensing Project brought together seven universities and cultural heritage repositories to digitally catalog over 10,000 images for use at participating universities (Stephenson 1999). Landsat imagery was being used for vegetation and land usage analysis by 1997, with references to work even earlier in the decade, though that work was primarily for studying vegetation (Driese et al 1997). The fact that this kind of early application for GIS technologies wasn't used for heritage work highlights how the field of historical geography needed to adapt those technologies to suit the needs of historians (Holdsworth 2002, Holdsworth 2003). While methods for creating virtual recreations of cultural heritage sites were being developed by 1997 (Marini et al 1997). Though largely limited to world heritage sites with cutting edge resources for the time, in this case the modelling process was developed for use on the Colosseum. What follows is a brief history of each field as well as related works this study drew influence from.

2.1 Digital Tools for Heritage

Early digital heritage efforts largely seem to be centered around online access for existing heritage datasets at institutions such as universities and archives (Stephenson 1999, Besser 1997). Earlier efforts to digitize anything beyond plain text ran into the fact that good quality images were too expensive to store digitally due to the technology at the time (Besser 1997). In 1997 the National Park Service began making Historic American Buildings Survey (HABS) records available to access online with the commitment to continue to add material as it was collected. This trend of providing digital access to physical resources continues into the mid-2000s though with scholars calling for a standardized methodology for digitizing and displaying archival catalogs (Quintero & Addison 2008). This suggests that at the time, the digitization of archival "back catalogs" had yet to reach academic maturity. The Council on Library and Information Resources (CLIR) is an organization committed to continuing to support digitization and access efforts, since 2008 CLIR has been funding projects to catalog and digitize "hidden" collections of archival data. CLIR has even contributed to some of the efforts of the Keweenaw Time Traveler with a grant to fund the transcription and digitization of employee record cards from the Calumet and Hecla Mining company located in the Michigan Tech Archives; this grant also supports their integration into the CCHSDI.

"Digital heritage tools" begin to include more than just archival information in the later half of the 2000s, in particular one starts to see a trend in more

diverse digital documentation tools such as laser scanning, photogrammetry, total stations, and other digital data collection tools; with these the question of how to most effectively integrate these tools into the more traditional documentation process became a pressing one (Quintero Blake & Eppich 2007). While full virtual recreations of physical structures existed before this time, they were largely limited to cutting edge projects on major world heritage sites such as the Colosseum in Rome (Marini et al 1997). With wider availability of tools such as 3D LiDAR scanning, digital modelling programs, computers capable of rendering 3D graphics, it becomes much more important for documentation efforts to include and standardize approaches to using these digital documentation tools and apply them across the larger fields of heritage preservation and interpretation (Quintero Blake & Eppich 2007).

While digital documentation of the built environment continued to develop into the 2010s, a larger change started to emerge in the idea of the digital *as heritage* which almost became intertwined with the usage of digital tools *for heritage* (Mezzino et al 2017). The 2010s saw the critical point of social media becoming the dominant driver of traffic on the internet, and a number of heritage fields have capitalized on this to start to utilize social media for heritage efforts (Jailot et al 2020, Casimiro 2019). Some have described this approach as a way to attempt to crowdsource heritage data such as photographs, personal stories and even things like oral histories (Jailot et al 2020). Casimiro suggests that this kind of approach may help to relieve some of the shortcomings of HGIS that date

as far back as its roots in historical geography when it comes to collecting and analyzing qualitative data (Casimiro 2010). In much the same way, others have argued that public participation in heritage research could lead to deeper understandings of how communities wish to interact with their heritage to help shape our efforts as heritage researchers towards the kind heritage communities *want* to engage with (Lafreniere et al 2019).

Within the field of HGIS this approach is known as “Public Participatory” GIS. By the end of the 2010s and into the 2020s digital heritage has embraced a pedagogy that recognizes emerging technologies will continue to provide new opportunities for not only answering cultural heritage questions, but in finding new questions to ask (Southall & Lafreniere 2019). Whether those questions require extensive social media campaigns, complex database and network analysis (Parrinello & Cioli 2019; Kreutel 2019), full virtual reconstructions of historic landscapes (Barceló et al 2019, Arnold & Lafreniere 2018), and more; it isn’t necessarily important for the researchers to use every tool at their disposal, but to recognize that new tools in digital heritage are being developed faster than ever before (Kermers 2020).

2.2 Historical GIS and Historical Spatial Data Infrastructures

Because the key datasets that this study utilized largely fall under the umbrella of historical GIS, it’s important to consider the history of the field. It is particularly important to acknowledge that HGIS not only draws from the technical and analytical experience in the fields of GIS, but also draws from the

theoretical and pedagogical framework of the schools of historical geography (Holdsworth 2002, Holdsworth 2003). Historical GIS, while present throughout most of the 1990s, largely remained limited to the visualization of populations at larger scales such as counties or parishes (Gregory et al 2002). The North American Population Project attempts to record link census microdata from both North America and Europe to provide opportunities for analysis at a scale far beyond what had been previously attempted (Ruggles et al 2011). As HGIS grew in its maturity in the early 2010s, scholars began to utilize the spatial analytical capabilities for studies on topics such as urban change (Sadler Gilliland & Arku 2011, Novak & Gilliland 2016), housing discrimination/segregation (Gilliland Olson & Gauvreau 2011, Tuckel Schlichting & Maisel 2007, Salder & Lafreniere 2017), mapping historical pandemics (Kennedy et al 2015, Lafreniere et al 2021). This interest in HGIS benefited from the 'spatial turn' in history (Withers 2009) and was largely facilitated by the establishment of common workarounds to circumvent the limited temporal extent of GIS software designed for use by municipalities rather than academia (Gregory Kemp & Morsten 2001, Knowles 2005). While these early approaches yielded methodological and technological insights beyond just the results of their studies, they were not without their own limitations.

On its developmental pathway the field of HGIS needed to adapt and find ways to overcome many shortcomings of both analytical approaches and GIS technology itself; the inadequacy of boundary data to truly represent the extent of human spaces, the limitations of displaying the temporal extent of features within

GIS software, and the incomplete picture that historical records often leave us with (Knowles 2005, Knowles 2015). Lock reiterates the persistence of these shortcomings into the 2010s, with a specific focus on the inability to present scale, both physical and temporal, in a way that is meaningful to those outside of the discipline of HGIS (Lock 2010, Lock & Pouncett 2017). While historians are acutely aware of the incomplete nature of the historical record, others have taken the opportunity to attempt to address these shortcomings in various ways.

One particular school of thought stems from Sherry Olson's work mapping a number of surnames across Montreal combining a number of different data sources across a large temporal extent from 1840 - 1900 (Olson & Thornton 2011). Later Lafreniere and Gilliland would build on all of these ideas in their "Imag(in)ing London Historical GIS Project" mapping both the built and social environments of London Ontario from 1871-2013 (Lafreniere & Gilliland 2015). This London HGIS demonstrated the potential that came with building a dataset not with the intent to address a specific research question, but to serve as a flexible framework to allow for the pursuit of a plethora of data-driven inquiries into subjects such as historical spaces, populations and social processes.

Since the CC-HSDI is the successor project to Imag(in)ing London, it differs from that project in two notable ways. The first way the CC-HSDI has advanced the HSDI approach is through its spatio-temporal linkages; linking

structures, business, people, and more across time. These robust spatio-temporal linkages allow for the study of any number of aspects of how communities change over time rather than how they existed just at one point (Arnold & Lafreniere 2018, Arnold & Lafreniere 2017, Trepal Scarlett & Lafreniere 2019). The second advancement made by the CC-HSDI is through its incorporation of public engagement; with funding awarded from the National Endowment for the Humanities a public interface was developed and launched as the Keweenaw Time Traveler (KeTT). KeTT not only allows members of the public to view query and share data from the CC-HSDI, but to contribute to it through digitizing information about the built environment from historical maps and through submitting their own stories personal stories and images to enrich and personally contextualize this data infrastructure (Scarlett et al 2018, Lafreniere et al 2019). The CC-HSDI sits at the apex of decades of development in HGIS, particularly in regards to its ability to facilitate “Deep Mapping” through spatio-temporal linkages and its robust catalog of data resources (Ridge Lafreniere & Nesbit 2013, Arnold & Lafreniere 2018, Arnold & Lafreniere 2017,Trepal Scarlett & Lafreniere 2019). It is important to note however, that this study is not fully utilizing the full potential of the CC-HSDI and is *not* doing any sort of “Deep Mapping”. This is due to the fact that the study site at Champion Mine has a limited amount of data available for it, nearly entirely lacking any of the temporal linkages that facilitate deep mapping.

The push for public engagement with the Keweenaw Time Traveler, and by extension the CC-HSDI provides an important link between the research based spatial data, and the call for data democratization from Cushing and Cowan. Beyond pre-existing efforts, more can be done to facilitate public engagement with this research infrastructure in a way that directly ties a general audience to a sense of place. Combining the spatial, temporal, and big historical data of the CC-HSDI with some of the AR approaches detailed in the next section is potentially one way to begin to explore the benefits of such an approach.

2.3 Augmented Reality

Ultimately the examples that follow only demonstrate a small sample of the work that has gone into finding novel uses for Augmented Reality technology, but still provide a solid foundation from which to start exploring the subject. Augmented Reality is an enhancement of the real world using digital tools to provide extra information to the user, providing a natural point of synergy with the kinds of spatialized data inherent in HGIS. This data driven enhancement can be done using digital displays, audio information, tactile feedback, or other means of sensory input. While digital display via smartphones is the standard of today, the first ‘true’ digital augmented reality display was developed at the University of Utah in 1968. It was only capable of displaying simple wireframe shapes within the confines of a single room, and required an apparatus that connected to both the user’s head and the ceiling, as well as a room sized computer to generate the graphics (Sutherland 1968). In this context ‘true’ denotes that the head mounted

display (HMD) in question displayed its images to both of the user's eyes, and was actually able to display information within a depth of field and enhanced the user's knowledge of a space, in this instance displaying symbols denoting the cardinal directions on walls of the testing room (Sutherland 1968). HMDs have largely fallen out of favor for consumer grade AR applications due to the relative ubiquity of smartphones, though some dedicated displays continue to be developed largely to suit the enterprise market, devices such as Google Glass and Microsoft Hololens. Systems designed for specific vehicles in the form of heads up displays (HUD) continue to show up occasionally in the consumer market, and are fairly common in military applications, particularly in avionics (Li et al 2013, Gill 2020). In the medical field AR has been tested for education to assist in training students on examining patients (Von Jan et al 2012), clinical trials have been run using real time imaging to augment surgical procedures (Heide et al 2018), and Hololens has been tested in conjunction with ultrasound to function as AR imaging (Nusheene & Bhupathy 2020).

Because of their relative ubiquity, smartphones have become the dominant platform for Augmented Reality applications and development, particularly so when it comes to educational and heritage focused applications. For example, Quick Response codes (QR codes) have been used to develop walking tours and disperse interpretive information (LeMire 2018, Davies 2014), while geolocation functions in smartphones have been used in tandem with GIS tools to create tours of historical events such as the Walk1916

app mentioned earlier (Cushing & Cowan 2017). At the higher end it is possible to project full 3D representations of individual structures or more onto landscapes, providing users with a sense of place for structures that are not present. One example of this was a project done by Louis Kaplan and Melissa Shiff, they used geolocated 3D models to create a proposed Jewish settlement on Grand Island in New York, allowing users to physically navigate the space and see what may have been (Kaplan & Shiff 2017). There continue to be calls for further testing and development of new ways of incorporating AR into heritage and education (Ellenberger 2017). Few have attempted to combine AR with HGIS to date, let alone an HSDI as robust as the CC-HSDI. The potential here is to push the boundaries of what those two technologies might be capable of, and potentially further our understanding of how those technologies can be used to support and nurture the heritage interpretations of the public.

3 Methodology

Going into this study it was important to identify what needed to be learned in order to determine how the augmented reality experience using AuGeo described earlier could be used answer the original research question. How can the integration of augmented reality with HSDIs support industrial heritage interpretation and education? As a result, this study was designed to focus on how the application changed participant's overall interest in industrial heritage, how it impacted the way participants explored the site, how their interpretations were shaped by both the app and the physical site, as well as identifying interpretations and inquiries they had after the study period. Data collection consisted of a survey sent to the participants before the study and a second more robust survey administered after the study. The pre-survey was meant to determine beginning interest and experience with the use of Augmented Reality while setting a baseline for participant interest in industrial heritage. After the pre-survey was administered, participants were transported out to the site (some chose to provide their own transportation) where they were given minimal prompting to then use the AR application to explore the site using the AR application. The post-study survey was designed to identify key areas of interest from the study site either digital or physical, to gather insights into participant's interpretations of the site, determine what participants valued about the experience, and to evaluate any sort of change in interest in industrial heritage.

3.1 An Augmented Reality Application for Supporting Industrial Heritage Interpretation and Education

Before evaluating how the integration of Augmented Reality technologies with Historical Spatial Data Infrastructures can support industrial heritage interpretation and education an application is needed to actually perform that evaluation. For this study a custom application was intended to be developed, but was unable to be completed and published in time to be used for the study.

In response to that setback the application AuGeo was selected. It was a natural selection because the custom application was based on the source code of AuGeo, the only main difference between the two is that the custom application allowed for the usage of georeferenced CC-HSDI Sanborn Fire Insurance Plans as a "basemap" in the application. However, number of other features factored into this choice. AuGeo is readily available on both the Google Play and App Stores for free. It is published as and ESRI Labs application, meaning it is readily compatible with all ESRI formatted GIS data and therefore the data within the CC-HSDI. AuGeo allows users to store spatial data locally, reducing the

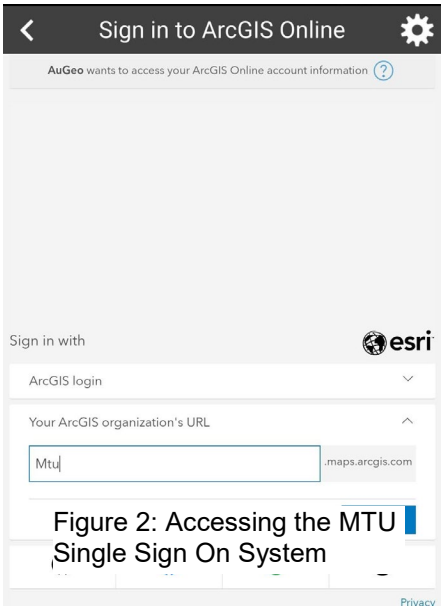

Figure 2: Accessing the MTU Single Sign On System

need for cellular data connections. Finally, it is also compatible with Michigan Technological University's Single Sign On (SSO) system, allowing the study participants easy access to all of the data they would need for the study.

Figure 3: AuGeo's Basemap Browser

AuGeo allows for the usage of "point feature classes" to overlay a mobile device's camera feed. A point feature class is a layer of GIS data that has been mapped to a specific set of geographic coordinates, and usually contains a set of attributes containing relevant information for that dataset. There are other forms of GIS data beyond points such as polygons and lines. However, AuGeo is only compatible with point data because it is the simplest to display in an AR format. Points within AuGeo display information as a "popup" that can be selected by tapping the screen to display descriptive text. Images contained within

Figure 4: A Point Containing an Archival Photograph of the Champion Mine Shaft No. 4

Figure 5: AuGeo's Navigational Map

the popup will be displayed, but cannot be interacted with. By clicking the compass in the bottom left corner of the display, users can access a map displaying both the direction the user is facing, and all of the points of interest around them. By clicking those points on the map AuGeo will provide users an approximate direction and distance to reach that point. As implemented for this study there were three different layers of point data implemented in the application. The first layer contained various pieces of information found in the Michigan Technological University archives such as photographs, newspaper clippings, and mining company documents. The second layer contained entries found within the 1939 Houghton County Directory. Each entry contained the individual's name and profession in addition to their address, which allowed them to be mapped to a corresponding address on 1949 Sanborn Fire Insurance Plans. The final layer was designed to make up for the fact that the Sanborn Fire Insurance Plans could not be used as a basemap in AuGeo, closeup images of each structure on the map were placed at the corresponding location in the point layer and titled with any descriptive information written on the Fire Insurance Plan.

Obviously a largely text description is not a good way to get an idea of an application's capabilities. To get a better idea of what this application is capable of, a video walkthrough can be found here: https://www.historicalgis.com/
To view the data itself readers can install AuGeo onto their mobile device unfortunately, the spatial data is only available to users with a Michigan Technological University login account via the SSO system login.

3.2 Participant Selection

The participants for this study were selected for both practical and mutually beneficial reasons. The 40 students in the third-year history course named "The Copper Country" (SS 3541) at Michigan Tech were selected as part of a collaborative effort with the course's instructor Dr. Laura Rouleau. This collaboration was mutually beneficial because this study also supported the course's goals in heritage education, specifically of landscape change of the Copper Country over time. These students were ideal candidates for a study like this because their technical literacy proved advantageous in streamlining the training process, and allowed them to use the Augmented Reality application on their own smartphones for both personal comfort and in optimizing set up time for the study, this approach maximized the time spent in the field using the app. Previous course activities also established background experience at industrial heritage sites with the class having previously visited the Quincy Smelter site in Hancock MI. However, the Quincy Smelter visit would prove to be

substantially different from this experience as that was a guided tour with no involvement of augmented reality or GIS technologies. While their enrollment in a course on Copper Country history generally implies at least some interest in industrial heritage, previous course material provided additional context for the industrial landscape they were exploring with the app.

3.3 Procedure

The study was conducted in four phases. The first phase consisted of visiting the class to provide training for the usage of the AR application, and to allow the students to prepare the application and needed data on their own devices. The second phase was the distribution of the pre-study survey designed to evaluate student's experience with Augmented Reality applications and determine a baseline for their interest in the field of Industrial Heritage. Phase three consisted of the actual on-site study; allowing the students to freely explore the Champion Mine site using the AR application, while this author provided technical assistance when needed. Phase four was the distribution of the post-study survey; designed to identify key areas of interest either digital or physical and gather insights into participant's interpretations of the site, while documenting any changes in overall interest in industrial heritage. Both the pre and post surveys were administered via Canvas quizzes by the course instructor Dr. Rouleau. This method of distributing the surveys was chosen to ensure ease of access for the participants, because Canvas is used in all Michigan Technological University Courses. This ensured all of the students would know where to find the surveys and that the surveys would be in

a place the participants would likely look on the day of the study. Additionally, both of these surveys are consistent with the qualitative design methodology used in similar studies (Cushing & Cowan 2017, Kaplan & Shiff 2017, Ellenberger 2017)

3.3.1 Phase One

During regularly scheduled class time on October 5th. 2021 a brief training presentation was given to the participants, this consisted of a primer on the Keweenaw Time Traveler and its component datasets, some background information on the types of data that would be in the application to provide some surface level literacy with those sources; and a step by step tutorial showing how to download AuGeo, access/cache the relevant data to be used during the study, as well as walk the participants through some ease of use settings they would want to know about such as the ability to manually control the Compass on the application.

3.3.2 Phase Two

The pre-survey was administered via Canvas quiz the morning of the study (October 7th, 2021). The survey was due at the beginning of class and contained the following questions:

1. Do you have experience using AR applications? If yes, describe it.
2. What do you anticipate learning from this experience?
3. What is your interest in exploring historical mining landscapes 1-10 with 1 being not interested and 10 being very interested.
4. Do you feel like this will be a valuable experience? How?

3.3.3 Phase Three

Participants were provided transportation to the study site via a bus leaving from campus immediately at 2:00pm. Some students chose to provide their own transportation to the site. The bus arrived at the stie at 2:15 pm a roughly 5-minute talk was given to explain the boundaries of the Champion Mine site, remind participants not to trespass on nearby residential properties, and to remind those taking the bus that it would be leaving by 3:00pm. Login information for the provided Wi-Fi hotspots was distributed and lastly it was reiterated to the participants that they were there to use both the app and the remaining site features to create their own interpretations. At roughly 2:20pm the participants dispersed around the site to begin exploring, they were given ~40 minutes to explore the area. During which time 4 students reported problems getting the data to load on their devices, which was quickly corrected by this author walking them through

Figure 6: Briefing the Participants Before the Exploration

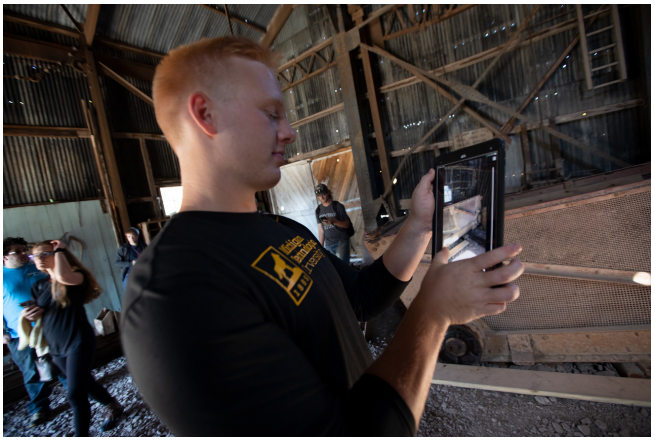

Figure 7: Participant Using the Application in the Shaft House

the login process to refresh the data. One participant reported difficulties with his device's compass, this author walked them through the activation of the manual compass control. One student had a failure of their device, it is unknown if it was due to damage or software incompatibility, which was rectified by providing them with an Ipad to use during the study. All of these issues were resolved within the first 10 minutes of the study. Over the course of the study participants covered roughly the entire grounds of the site, using the various datasets and the AR application to navigate. The sites that seemed to hold participant's interest the longest were the insides of the "Hoist" (Figure 4) and "Shaft" (Figure 3) houses. This is likely due to the abundance of physical artifacts present in both spaces, allowing for a myriad of both digital and physical interpretations to be made. Ultimately it seemed like there was not enough time for participants to thoroughly explore all of the material available within the time frame, particularly when it came to the residences adjacent to the

Figure 8: Participants Discussing Data From the Hoist House

Figure 9: Participants Viewing the Landscape Through the App

Champion Mine site. This may be due to a reluctance to disturb current residents, or to stray too far from the group and transportation.

3.3.4 Phase Four

The post-survey was administered via Canvas quiz and was made available immediately after the class period until midnight to ensure the experience was fresh in the participant's minds when filling out the survey. The post-survey contained the following questions:

1. Did this experience match what you anticipated learning? How? If not, why?
2. Did anything at the site (physical or digital) stand out to you? What and why?
3. Describe how the AR application impacted how you explored and interpreted the landscape we visited today.
4. Describe how the landscape has changed over time.
5. What questions about this site do you still have? How might you answer those questions?
6. After using the AR application rate your interest in exploring historical mining landscapes 1-10 with 1 being not interested and 10 being very interested.
7. Would you use technology like this again if it were available?

3.4 Concerns

The primary concern when organizing this study was the availability of a study site. In the initial planning phase of this study a section of downtown Calumet along Fifth Street was selected, this was due to the ready availability of data to be used via the Keweenaw Time Traveler and Copper Country Historical Data Infrastructure (CCHSDI). However, as the study date drew nearer there was concern that the participants would be unable to get back from the proposed study site in Calumet within the available time frame without significantly sacrificing time exploring the site. This concern was due to a delay in construction on the Portage Lake Lift Bridge. This led to the Champion mine site being selected as the alternate site. However, beyond just travel time, the Champion Mine supported not just the study through its status as an industrial heritage site, but through the fulfilment of the course requirements of landscape change that needed to be met in collaboration with the study. It was later learned that the utilization of this site also further supported the larger goals of the IHA program by cultivating community relationships by making connections with the caretakers of the site. One of which, Scott See being, a graduate of the Industrial Archaeology program. It should also be noted that the datasets described earlier in this section needed to be constructed to compensate for this change in venue, rather than just using the readily available data within the Keweenaw Time Traveler.

There is also a concern that the fact that the surveys were administered by the course instructor may have influenced responses. There may have been

an influence to provide more positive responses due to the lack on anonymity required to match up the different responses. However, it was determined that ease of access was more important than anonymity. Paper surveys administered on the way to and from the study site were considered, but rejected because some students preferred to provide their own transportation to the site, and ensuring that was an option was important due to the ongoing Covid-19 pandemic making travel by bus a concern for some students. The surveys could not have been administered at the Champion Mine because that would have taken up too much of the class period that would otherwise have been used to explore the site.

Other minor concerns were wireless signal and technical issues. Wireless signal was addressed by visiting the site beforehand to test device connections, and providing wireless access points to ensure network access was available to all participants. To address potential technical issues this author was available to provide technical support, and Ipads with the correct software and data were prepared in case for some reason participants did not have a device of their own or there were any other reasons they could not use their own device (such as software incompatibility, dead batteries, or hardware failures).

3.5 Ethics

There were a few areas of ethical concerns that were considered; the first two of which were the use of the application itself, and that of the potential physical

hazards to participants that naturally come with the Champion Mine site being a partially remediated industrial site. The application makes users aware that it will be using location data and the rear facing camera (permissions agreements the participants are already familiar with), and a verbal reminder was given to participants at the beginning of the study not to trespass on private property beyond the outlined heritage site and to be mindful of potentially dangerous items still located at the site. The main concern that could potentially affect the results of this study is the potential for students to have felt pressured to respond positively in the survey because it was administered by Dr. Rouleau, their course instructor. For IRB approval it was determined that this project was covered under pre-existing IRB approval for the Keweenaw Time Traveler Project.

4 Results

Out of 40 students in The Copper Country course 31 students responded to the post-survey, with one of those respondents having not responded to the pre-survey; a response rate of roughly 75%. 18 of the respondents reported having no previous experience with Augmented Reality, 12 reported some experience, largely through AR mobile games such as Pokémon Go. This demonstrates that this sample had little more than passing familiarity with AR experiences before this study, suggesting that their responses were likely not heavily influenced through previous experiences.

4.1 Change in interest

Before the study participants reported an average interest in Industrial Heritage of 8.34 on a scale of 1 to 10, supporting the idea that these participants had an initial interest higher than most people. However, without a larger control group this is unverifiable. After the study their reports showed an average interest of 7.85 out of 10 with 5 respondents showing slightly increased interest and 9 respondents showing reduced interest. Some of this average decrease can be accounted for through two outliers showing

Table 1: Description of Participant Change in Interest

Number of students with increased interest	5
Average increase	1.6
Number of students with decreased interest	9
Average Decrease	-2.52
Overall average change	-0.49
Standard Deviation	1.51

decreased interest, with their reported decreases in interest of -4 and -6 falling more than 2 standard deviations outside the norm for respondents. However, these outliers do not account for all of the negative change. Some of this may be due to fatigue from respondents needing to fill out both surveys on the same day of the study, administering the pre-survey during the original consultation with the class may alleviate the possibility of this fatigue in future studies.

4.2 Respondent Experiences

Responses were classified as "positive" "negative" or "mixed" based on explicit statements of those experiences as well as a more arbitrary determination of tone. Some responses are included to give an idea of what types of responses were classified in each category. 19 respondents described experiences that were characterized as "positive". Some common sentiments expressed included 5 responses noting that respondents liked the "freedom of exploration" the app allowed over guided tours, 7

Table 2: Participant Experiences and Expectations

Positive Experiences	19
Negative Experiences	6
Mixed Experiences	6
Met Expectations	23
Did Not Meet Expectations	8

"*I was expecting the app to give a sort of self-guided tour and it did not disappoint. It pointed out key features of the landscape for us to explore. It was easier to get a visualization of all of the parts of the mine as they might have worked in their heyday."*

"Although present day the site was run down and abandoned, using the AR app really made the site come alive and make it interesting and informative!"

Figure 10: Examples of **Positive** Experiences

responses highlighted how they felt the app showed them information they would not have otherwise been able to find at the site. 6 responses were characterized as “mixed” experiences, many of these responses expressed a desire for the application to provide the participants with more detailed or specific information about buildings/events/people. 6 responses were categorized as “negative” experiences, some of them also expressed a desire for more specific information to be displayed within the app, 3 mentioned technical issues that went unreported during the study and 4 expressing a more personal dislike of the application or a preference for unaided exploration.

> *“Overall, the experience of using AR synced with my anticipation of learning given that the tool was able to help me understand the buildings that I was in. I was able to see and learn about the buildings while exploring the area unguided. Overall, however, the AR tool was less conducive to my learning experience than a tour guide would have been. In general, I think I would have learned significantly more about the area and the buildings if we had toured the area in a guided fashion. In many ways, the AR application felt distracting to the experience. I often avoided using it once I was in an area to ensure that I could physically enjoy the space that I was in.”*

Figure 11: An Example of a **Mixed** Experience

> *“I anticipated the AR experience to feel more integrated, maybe it is just my personality but I was more interested in seeing what was directly in front of me rather than virtually.”*
>
> *“I used it for about 5 minutes then put my phone away and instead looked around and wandered without it. It did not impact how I interpreted the landscape much, if at all.”*

Figure 12: Examples of **Negative** Experiences

4.3 Other Findings

24 respondents reported that the experience met their expectations and 7 reported that it did not. These unmet expectations heavily correlated with "mixed" and "negative" responses. 9 responses specifically mentioned some way in which the app helped them to navigate around the site. 18 respondents reporting they would use a similar application again, 12 respondents reporting that they might use one, and 1 reporting that they would not. In keeping with the goals, the of the "Copper Country" course when asked to elaborate on how they were interpreting the site and or the post-industrial landscape all but one respondent was able to elaborate on some interpretation they were able to make about the make. Also relating to the course goals, the final question prompted respondents to elaborate on questions they had about the site, and how/where

> *"The AR application impacted how I explored in that it led me to places that did not stand out, but stood out on the app itself."*
>
> *"It provided a rough direction of where points of interest were."*
>
> *"The AR application primarily acted as a tour guide for me in wondering around the site."*
>
> *"I had some difficulties getting it to work which might have been the compass on my phone. When it did work, the popups helped to guide me to new places to explore or read more about."*

Figure 14: Examples of Responses Stating the App Aided in Navigation

> *"I would like to know more details regarding production rate, depth of the mine, number of employees etc."*
>
> *"I am still curious as to some of the purposes of the buildings on the property. I was unable to perfectly visualize the process of copper extraction at this site."*
>
> *"How deep is the mine shaft? How much copper was taken out of this mine? How many people worked here?"*

Figure 13: Examples of Inquiries

they might go to find that information, only 3 respondents did not elaborate on further inquiries they wanted to make about the site. These inquiries are also important moving forward as they will help give direction in how to improve the application and address the shortcomings noted in the mixed and negative responses. It should be noted that these responses likely include error of their own due to factors such as the way they were administered discussed earlier and that these surveys were not professionally designed, meaning the questions may not have yielded answers perfectly suited to answer the original research question. However, the information gathered in this process still provides a valuable opportunity to discuss how this application performed and how the future implementation of augmented reality in industrial heritage education and interpretation can be improved.

5 Discussion

This study demonstrated that there is potential for AR to serve the fields of industrial heritage and education as a navigational tool for heritage sites, particularly ones that occupy larger landscapes with potentially significant missing structures. With nearly 1/3rd of respondents specifically mentioning how the application helped them navigate the site, this demonstrates a potential avenue for further study to "dial in" the types of information and modes of presentation through AR that would most effectively allow users to navigate such heritage site. This result is encouraging for this line of inquiry as it was unexpected and did not stem from any specific questioning, and no responses demonstrated that the application made it more difficult to navigate the site.

While the overall tone of responses demonstrated a majority positive experience with the AR application with roughly 60% responding with entirely positive feedback, only 18 out of 31 respondents replied that they would use a similar application if available, leaving the vast majority of the rest of the responses (12 out of the 13 remaining) unconvinced with "maybe" answers. This demonstrates that there is still a question of whether or not this AR tool really is valuable in this use case, especially with the responses indicating an overall decrease in heritage interest (even when accounting for outliers). For the responses coded as "Negative" (6 response) and "Mixed" (6 responses), there is a clear correlation to unmet expectations (8 responses), as well as technical

issues (3 responses) and/or some other general dislike of the application (4 responses). Technical issues will always be a problem when evaluating any sort of digital resource and it is inevitable that some users may just not like using technology. However, there is the potential to try and address those unmet expectations.

Feedback describing a perception of 'shallowness' is largely consistent with findings of other similar studies such as the ones undertaken by Cushing and Cowan (2017) and Kaplan and Schiff (2017). In the context of this study, it is unclear if these shortcomings are due to unrealistic expectations set by participants or if the original consultation with the class set expectations that would never have been able to be met by the testing application. However, with some improvements to the application allowing for more detailed information about specific data such as; company records and personal experiences, many of the criticisms and disappointments experienced by participants could be assuaged. One way in which those improvements could be made is by focusing on specific historical narratives in a similar fashion to other AR heritage projects like the "Walk 1916" and "Mapping Ararat" projects discussed in the literature review (Cushing & Cowan 2017, Kaplan & Shiff 2017). Though, this solution comes with the caveat that those studies also experienced similar issues with a perceived "shallowness", perhaps different results will be found by utilizing the different datasets within the CC-HSDI? Another way in which this could be explored is by performing a similar general study at another heritage site that has

more robust historical spatial data available than at the Champion Mine, sites such as the Quincy Mine and Smelter, Main Street Calumet, Michigan Technological University's campus, and many other sites located within in the Copper Country. These perceived shortfalls could also be addressed at the design stage of the application itself, by allowing a greater degree of freedom for users when interacting with the application, for example allowing users to zoom into images to allow for more meaningful incorporation of datasets such as company records or newsprint. By implementing one or more of these potential solutions, further inquiry should likely find a more positive reaction from participants, suggesting the potential for tools such as this to bring positive industrial heritage and education experiences to users. Given these findings, it seems to be too early to truly consider how implementing AR applications such as this might impact heritage organizations. However, further including heritage organizations in the development of these applications may provide valuable information in how to best tailor these applications to fit their needs. Were this author to undertake a similar study, it would ideally be done at one of those more data-rich sites listed previously, and the design of the application would incorporate the ability for users to more freely interact with the images displayed by the application.

Another way in which an application like this might be utilized is to more specifically study the idea of Data Democratization. A concept introduced to this author by Cushing & Cowan's (2017) work, Data Democratization is the idea that

data which is traditionally used in university settings for research purposes should be made readily available to users outside of that setting to allow them to create their own interpretations outside of the perspective of researcher's monopolization of those resources. This meshes with the public facing goals of projects like the Keweenaw Time Traveler, especially with the elements of public participation that project has already incorporated (Lafreniere et al 2019). Bringing the full breadth of the CC-HSDI into an Augmented Reality interface not only provides another way for users to interact with that data aside from KeTT, but provides users an opportunity to interact with that data within its original spatial context in ways they could not before. Using AR and HSDIs as way to support Data Democratization represents an opportunity for users to continue creating their own new interpretations. This idea is supported by the findings of this study as all of the respondents were able to come up with some sort of interpretation of their own, and all but one respondent was able to formulate an inquiry about something else they wanted to learn about the site.

To reconsider the original research question:

How can the integration of Augmented Reality technologies with Historical Spatial Data Infrastructures support industrial heritage interpretation and education?

Ultimately this study showed that there is the potential for AR to be used to support industrial heritage interpretation and education by augmenting

interpretive materials and providing users with the freedom to navigate and explore sites using their own devices. However, it also demonstrated that the design of these applications is important and needs interactivity and depth to meet the potential needs for users. These results serve as a call for future studies to incorporate these findings into applications that will more effectively serve the needs of heritage organizations moving forward.

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A Appendix

Table A.1 Pre-Survey Questions and Responses

Attached

Table A.2 Post-Survey Questions and Responses

Attached

B Photo Copyright documentation

Figure 6: Monte, Matthew, photographer. “A52A6876” Photograph. Houghton, Michigan. Michigan Tech Social Sciences. From *mattmonte.smugmug.com*. https://photos.smugmug.com/MTU/MTUSocialSciences/PainesdaleMineAugReality/n-cRSgdN/i-j2HsLvL/0/42cbb5e2/X2/i-j2HsLvL-X2.jpg (accessed November 9, 2021)

Figure 7: Monte, Matthew, photographer. “A52A6899” Photograph. Houghton, Michigan. Michigan Tech Social Sciences. From *mattmonte.smugmug.com*. https://photos.smugmug.com/MTU/MTUSocialSciences/PainesdaleMineAugReality/n-cRSgdN/i-NKr2HSS/0/138b3faa/X2/i-NKr2HSS-X2.jpg (accessed November 9, 2021)

Figure 8: Monte, Matthew, photographer. “A52A6966” Photograph. Houghton, Michigan. Michigan Tech Social Sciences. From *mattmonte.smugmug.com*. https://photos.smugmug.com/MTU/MTUSocialSciences/PainesdaleMineAugReality/n-cRSgdN/i-KJ4WNg2/0/25cdb5ad/X2/i-KJ4WNg2-X2.jpg (accessed November 9, 2021)

Figure 9: Monte, Matthew, photographer. “A52A6948” Photograph. Houghton, Michigan. Michigan Tech Social Sciences. From *mattmonte.smugmug.com*. https://photos.smugmug.com/MTU/MTUSocialSciences/PainesdaleMineAugReality/n-cRSgdN/i-m7bgXRq/0/e6d3d67a/X2/i-m7bgXRq-X2.jpg (accessed November 9, 2021)

Pre-Survey questions and responses			
Do you have experience using AR applications?	If yes briefly describe that experience:	What do you anticipate learning from this experience?	Please rate your interest in exploring historical mining landscapes
No		An interactive experience to learn more about the history and be able to relate to its location/environment as seen today.	6
No	I have never used any AR applications before.	I anticipate to learn both how to use AR technology and some cool history of the site in Painesdale we are visiting.	10
No		I anticipate learning how to use the AR kewennaw history map, and some history about the copper country.	9
No		The use of technology and what it can do for history.	10
No		Learning more about painesdale mine and the applicability of augmented reality to tourism/ museums.	8
Yes	Kinda janky, but cool none the less.	Lots of niche and interesting history stuff.	6
Yes	I have only played Pokemon go a few times and many years ago. Occasionally I will use Amazons AR feature to let you see objects in your room.	I hope to learn some history as I am walking around as the app gives us a sort of tour of its own. We are able to explore what we are interested in as we are literally walking through history.	8
Yes	Yes, briefly played Pokemon Go in 2016.	I expect to learn more about the copper mine and other interesting historical artifacts that may be in the app. I also expect to learn more about AR just by using the app.	8
No	NA	How the land is use in changed from the past to the present	5
Yes	Minecraft AR app Google glass demo Hololens demo	Some info about the workers at champion	8.7
No		I have no expectations/anticipations.	7
No		I want to learn the applications and possibilities of AR. I also want to learn from the app and explore a mine shaft.	10
No	No previous experience	I think it will be neat to be able to see what used to be there, when compared to the current day	9
No	NA	I hope to learn how AR can interact with our surroundings especially in a historical sence. The blending of cutting-edge technology and recalling the past is very interesting to me. Additionally, I hope to gain insight into the people and places that existed at the Champion mine during its golden years.	10
Yes	PokemonGo, primarily, however I have also utilized apps like Starcharts for stargazing as well.	I anticipate it being a unique experience for learning about a historical site while actually being at the site; being able to see pictures and read about historical situations while actually being present and being able to see and feel the location. I'm very excited.	10
No	N/A	I am excited to learn about how the past landscape once looked using the the AR application. I think it will be a great experience and a very convenient one!	10
Yes	I believe you said video games used this (Mario Kart and Pokemon Go). I've played those before.	I think it will be cool to see what the app provides and learn about the area in the time of its operation.	7

No		More about the mining history at the visited location in a more interactive way.	10
No		I expect to learn how this new technology can help us understand historical sites better.	8
Yes	Played Pokemon GO, and the AR emojis/bitmojiis on different social medias	I think it will give a better perspective. Its one thing to see pictures of a place, its another to actual go and see something in person. Being able to show things that used to be somewhere will just help us get a better picture of what was there.	7
No		I don't know	7
No	No prior experience	I anticipate the use of AR being additive to the experience of exploring the historical landscape we are going to visit. I hope to be able to interact with my surroundings in a way that isn't possible without the use of technology to hopefully gain different perspectives on the place that I am visiting. One thing that I am hoping this experience is not is a distraction; if the use of technology distracts from my ability to understand and explore the historical landscape, then I see its use as an obtrusion on the experience.	8
Yes	Pokemon go, using depth sensors to map out a room on	History about the copper country I didn't know	8
No	No.	Some history at the location.	10
No	I have no experiene	I hope to learn about how AR can be used to help others learn about the environment around them.	10
Yes	I played pokemon go alot during freshman year as well as the mario kart ar game at friends houses.	I would love to learn more about the buildings and history of the architecture around the Keweenaw.	8
Yes	Pokemon Go The Nintendo 3ds had some AR games although I haven't played them in a very very long time	About the local area and the history behind it. About how AR can be used to more effectively learn about information and history of the area as we are currently in it.	7
Yes	I have used basic AR applications in some games on my phone.	I expect to learn more about the area and what events took place.	7
Yes	Playing Pokemon Go	Where buildings used to be located and what they were used for.	8.5
No	N/A	How the equipment works and how it can be useful	10

Post-Survey questions and responses							
Did this experience match what you anticipated learning?	How or how not?	Did anything at the site (physical or digital) stand out to you? What and why?	Describe how the AR application impacted how you explored and interpreted the landscape we visited today:	Briefly describe some ways the landscape here has changed over time:	What questions about this site do you still have? And how might you find more information to answer those questions?	After using the AR application rate your interest in exploring historical mining landscapes	Would you use technology like this again if it were available?
Yes	It was cool to be able to point and see the articles.	It is crazy to use around and see how much some areas have changed and how some are still similar.	It was cool to look back in the past and see how the landscape has changed. However, I still also just enjoying the areas and historical areas as they are today.	Some buildings have been around for a long time but the campus has gotten bigger and there are new man-made additions to the landscape. Also there is a fairly large human impact due to the increase in roads and housing in the area.	Will there be AR around more areas that shows the history and/or other information about the area? I could look on google for any AR projects and similar apps.	7	Maybe
Yes	The technology did match how I expected the AR to work in regard to the device interaction with the surrounding environment. I was, however, expecting a little bit more information from the app when buildings or structures were found. I know that this is still under development so more will likely be added or it could be due to my incorrect use of the technology since I was only using the one data source which showed the mining operations buildings.	The preservations of the buildings stood out to me, especially the mining captains office. The vast amount of records and information present in that building was stunning. Regarding that app, I did enjoy not having to guess what each building was used for as the app clearly separated (both with visuals and distance markers) what each building was.	I would say it made me realize the different types of structures present. Normally at a site like such, without a tour guide I would be able to pick out a few of the obvious buildings such as the rockhouse and hoisthouse and would look at most other surrounding structures with curiosity and wonder as to what they were used for.	Most obvious would be the decay of the buildings and structures, with some in good condition and others collapsed. After looking at some of the photos in the mining captains office, the amount of trees and vegetation was next to zero back during operation which vastly contrasts to today. Also, the newer buildings would not have been there such as the new privately owned garage/shop near the warehouse.	I would like to know more details regarding production rate, depth of the mine, number of employees etc. I hope that such information will be easily obtained while using the finished version of the app if possible.	10	Yes
Yes	I anticipated learning about landmarks and stories at landmarks that are relevant to the mining industry.	The machine shops stood out to me, they are very large structures with beautiful stone work.	The AR application aided in my understanding of the landscape and what everything was, as well as the stories behind them.	Simply put, the landscape has aged and deteriorated over time. The pictures on the AR helped show that.	I have no further questions about the site.	9	Maybe
Yes	Yes, we got to use technology in a way that's much different from that of what we're used to.	The big swinging arm on the side of the building , I couldn't figure out what it would have been used for.	It got us looking In places you wouldn't think	The shaft building is deteriorating, foundations are beginning to crack as well.	I really wish we could see underground in the mines, I'm curious as to what it looks like when you're being lowered in the man car. I could do some research and find pictures.	8	Yes
Yes	I was surprised at how accurately placed the site markers were placed. My only recommendation would be to replace the zoom slider in the app with a radius to see markers. I know this is an option before, but it would be very nice to not have to change screens to use it.	Though the shaft was in good condition, I was amazed at how ramshackle the operation seemed even when it was so deep.	There were a few names for a lot of the buildings that I would not have had an idea of. Given more time, "stories" attached to the bubbles would be nice too. Overall I thought it was a positive tool to have with me.	Foliage has increased significantly, it looks like shaft no 3 (which I would not have seen were the app not being used) was tied in series to shaft 4.	I shall look at the keweenaw website to learn when it closed.	8	Yes
No	The ar stuff did not work well at all on my phone. That iPads that were there I did not try, but I saw someone using them, and it looked much better on those.	I thought the mineshaft man car was super cool. It also is crazy how much stuff is still there. There were records from the 1940s in a book laying on the ground in the (winch) house	I ended up not really using it unfortunately my phones internal compass was too wacky to work with the app well.	There is a lot more vegetation than I imagine there would have been back in the prime days of the mine.	I want to see more pictures of how it used to look like, I could probably find these types of images in the archives.	8	Yes
Yes	I was expecting the app to give a sort of self-guided tour and it did not disappoint. It pointed out key features of the landscape for us to explore. It was easier to get a visualization of all of the parts of the mine as they might have worked in their heyday.	I was impressed by how well preserved certain aspects of the mine were. I can tell many put a lot of time into the presentation of the mine and its current state.	The app mostly directed me where to go. I would see a banner close by and gravitate towards it. It was very easy to see the names of some of the buildings and some of their basic functions, as long as the compass was pointing in the proper direction.	Of course this would have been a much more bustling center back at the time of the mine's full functionality. Since its closure, the site has been preserved and renovated in some cases to maintain it's look. Some aspects of the mine were likely cleared out to make the site more presentable to tourists. It was also unfortunate to see that the state of the surrounding community was in decline. It is likely that specific area will never see as much money flowing in as it had during the mine's operational years.	I am still curious as to some of the purposes of the buildings on the property. I was unable to perfectly visualize the process of copper extraction at this site. In the future I will likely be exploring on google, in the MTU archives, or the Keweenaw time traveler website.	8	Yes
No	The app did not work on my iphone. I ended up sharing the app with one of my friends so all in all it worked out!	Just overall how small the site was compared to Quincy. I do like that this project is starting at a smaller location though. It seems like it was easy to handle with the app when I was using my friends phone.	I liked that you didn't necessarily need a tour guide when walking through the area but, I felt like I was staring at the phone more than I was looking at what was in front of me. I ended up stumbling around the site from me looking at the phone so often. I personally like looking at what is physically in front of me rather than looking at my phone but, overall the app was nice when giving dates of certain things.	There are more trees and the buildings are worn down/ falling apart whereas back in the day they were fully operational.	There was some equipment/ pipes that were just lying around and I personally couldn't find any info on that through the app. I would have liked to find out more about those things at the site. Maybe in the future have a tour guide there if there are any extra questions.	8	Yes
Yes	I walked around and learned about the environment and how it was used in the past	It was difficult to work initially and I needed assistance on how to download the data and work the interface so I noticed I'm not using friendly interface but I assume that will be fixed	It was annoying having to look at the phone screen instead of environment around me My phone was slow to pop up any information so I felt like I was very delayed and it was ruining my experience. I would refer to have a person there telling me about it instead. I do think I would change my mind if the app to work better for me	The landscape changed by the use of mining they cleared out the forest so that was there before and people built around the mine to live there. The house is wouldn't have been built if the mine was not successful in the mines would not have been built if there was no copper there	I have questions what the mind would look like underground and how the workers really did work down there. I could find more out by listening to a primary source that is a minor talking about his work experience and how his life was. This could be found online or maybe in a book	3	Maybe
Yes	I expected to get some additional info, which I got.	The site was cool, but small, smaller than many other mine sites around the Keweenaw, it was interesting.	I used it to supplement what I was seeing, though i'm more of a 'see with my eyes' type of person, so it wasn't that heavily used.	There's a collapsed building, the pipe is gone, the engines no longer move, and there's a lot of rubble.	What specific buildings were for and what year they were built, if the walking path up above is still used and maintained, when that was built. If I went on a tour and asked a guide I could probably find out small specifics.	8.5	Maybe
Yes		I pointed the AR at some building and it told me what they were used for. I was like 200 ft from the buildings.	It was really cool for pointing where to explore because it would show things even far away.			7	Maybe
Yes	I learned about the details of the champion mine and I learned how to operate AR.	The angle of the hoist/shaft. The angle was very great and I did not know that the angle changes for how south you go in the copper country.	It gave a lot of details that would have taken a long time to explain if a tour guide was used.	The trees grew up in the area. Houses and buildings were deteriorating.	Where was the stamp mill and how did the ore get to it.	10	Yes
Yes	It was very neat to see the buildings that intact. The application was also neat to experience - as it helped to see things such as photos of buildings that weren't there anymore.	The hoist was very neat to go inside and see how it operated, how workers were brought down into the mine, and seeing the large winch that lowered and raised copper and workers down into the mine was pretty neat.	The application pointed out some valuable information that would have not been noticed. I think it was very neat to see the houses of who worked at the mine as well.	Trees have grown up, concrete has degraded, some improvements have been made to the site such as handrails to make everything more accessible, but primarily the site has just been overgrown.	I would like to see more photos and layout of the site, and to do that I would use the application shown in class.	9	Yes
No	I anticipated the AR experience to feel more integrated, maybe it is just my personality but I was more interested in seeing what was directly in front of me rather than virtually. I think the virtual reality experience would be very valuable for those that want to tour remotely or due to accessibility issues cannot visit the site in person. Using technology similar to google street view could bring a whole new opportunity for patrons to visit the site.	I enjoyed seeing the preservation and work done to the site, especially considering this shaft #4. is the last of the copper range. Also, it was interesting to see electric motors used as hoisting engines rather than steam-like at Quincy.	The AR application interface was relatively easy to use and offered some good detail in regards to the area and site. It did change how I would have normally explored the site, as normally I like to take in my surroundings without the aid of technology. But the supplement of information allowed for an almost self-guided tour.	Based on the ARCgis mapping and data from Keweenaw time traveler the landscape certainly changed over time. Buildings that once stood like the Change house and Copper Range Barn no longer are evident at the site. While others like the machine shop seem to be privately owned and renovated.	I am curious about the specifics of this mine and hoist in general, what type of copper deposit was mined here? What years were the most profitable? How many levels were mined, and are any still accessible? I would imagine I could find out this information from a guided tour of the site, but possibly even records from the Keweenaw time traveler.	10	Maybe
No	It was hard to navigate the AR interface and wasn't particularly intuitive. Additionally, I could not pull up or enlarge what pictures I saw on the interface.	The shafthouse stood out the most to me physically. Digitally, the shorter labels and titles stood out most. The shafthouse because it was physically imposing and had the most interesting features, and the shorter labels and titles were easiest to read and least cluttered.	In all honesty, it didn't impact my exploration of mining landscapes that much, as I was already able to identify many of the structures. I really enjoyed the physical signs and I think it would be really cool if the AR interface was more like a virtual museum with explanations and such.	The growth of forests and other undergrowth has significantly changed the landscape. Additionally, the old rail routes are gone and a lot of the external infrastructure of the mine is gone. External as in outside of the buildings. Finally, a lot of the buildings themselves are collapsing or have structural damage and disrepair. A drastic difference between then and now.	My questions largely pertain to how to best operate the site. I feel like there was a lot of information I was missing out on but I didn't know how to access it or if it even existed. I feel like answers to these questions could be found either with the producer of the app, a tutorial, or through a lot of fiddling, which would have been fine if we had more time.	10	Maybe
Yes	I thought it was super interesting being able to use the AR at the Painesdale mine site and see the history of the area. It was so interesting learning about the background story of each building, and the city directory involved with the area. Although present day the site was run down and abandoned, using the AR app really made the site come alive and make it interesting and informative!	What stood out to me the most is the artifacts inside the buildings that were left there from the past. I thought it was super interesting seeing the old paint cans, the old machinery, and even the old worker boots that were there. It felt like I was walking into a place that has been preserved, with just a bit of dust.	The AR application impacted how I explored in that it led me to places that did not stand out, but stood out on the app itself. It was cool seeing the different pop-ups on the app and the images related to the pop-ups. I interpreted the landscape differently by using the AR application because I was able to see the schematic of what it looked like back in the day, as opposed to the run down buildings present today.	One way that the landscape at the Painesdale mine changed over time is the removal of the railroad that was beyond the shafthouse. Prior, there was a railroad that was supported on a bridge on the south side. Today, it is just a walking trail that overlooks the site. Another way that the landscape changed over time is the surrounding houses. Back in the day, these houses were kept up and had mining families living in them. Today, most of the houses are falling apart, or have workers working on them to restore them.	One question that I have about this site is the building to the southern right side of the shafthouse that contained the huge metal cylinder. I am assuming that this was a boiler of some kind, but I am not sure. I could find more information about this building by re-visiting the site and using the AR application, or by using the Keweenaw Time Traveler website once it is updated.	9	Yes
Yes	I thought it was cool to see the physical mine location and understand the area the mining took place. The app helped tell some of the things that used to be at the location but have since been torn/run down.	The mine shaft house - the size of it I thought it was cool to find out that there used to be a bowling alley on site at the mine.	I thought it helped a little bit in terms of seeing names of things and buildings. I had a hard time understanding exactly where the buildings would have been standing during their operation because the app only listed the name and a general distance/area without real certain specifics with a pinpoint on my camera or something.	Lots of building have been removed, taken down, or run down due to age. I imagine a lot of the vegetation and overgrowth that is in the area now was not there during the time of the mine operation as well.	Did this site outsource the copper ore found to the Quincy smelter?	7	Maybe
Yes	I learned more than I thought I would have.	I drove by the site hundreds of times, but I never realized the magnitude of how large everything was.	It helped understand what each piece of the site I was looking at.	There are now trees and vegetation growing in the site. The buildings are starting to rust and corrode. It was nice to see it is being preserved and not torn down.	What were the conditions at this mine compared to other mines in the area? I will look into it at the archives.	10	Yes
Yes	Yes, it was interesting to see the different structures along with the popus that asked questions or provided more information in the AR app.	Yes, it was really interesting to see the inside of the main shaft house. I could see the car they used to move material/men/supplies up and down the shaft. It was cool to physically see some of things we read about in the readings.	I had some difficulties getting it to work which might have been the compass on my phone. When it did work, the popups helped to guide me to new places to explore or read more about. The questions helped to think how the site varied over time from opening to closing.	There are less structures now then back when the mine was operational. Either from deliberate demolition or natural decay. There is also more vegetation today from all the overgrowth that has occurred since the mine closed.	How successful was the mine and how long did last? The information could be found in the achieves, unless it is more readily available, such as a book or website.	10	Yes
No	I couldn't get my app to work. This could have been a user error though. I still enjoyed seeing the mine and walking around!	The trust miners had in the equipment back in the day to lower them thousands of feet underground.	Mine unfortunately did not work.	The buildings are a little more run down but the structure for most of them is in great shape! I'm sure there was a lot more commotion back in the day too.	How much was this mine producing? I'm sure I can find this information online.	5	Yes
Yes	It basically matched my expectation. At least on my phone however it would take some time before the app would catch up to where I was actually looking. It only every took like 5-8 seconds but i did have to point it at something and then wait a while. I do think that it would be nice if there could be super imposed images or renders of the buildings that are no longer there. It would give a good sense of scale.	I think the hoist house was very impressive and in pretty good shape.	It helped me identify some of the buildings that were not marked very well.	The buildings in general are in pretty good shape but they looked aged. There were definitely some buildings that used to be there that are no longer there.	I don't really have any other questions about the site. Though I think the Keweenaw time traveler website or the library archives would be good places to learn more information.	7	Yes
Yes	Ar is a gimmick and doesn't really add any thing to the experience	The angle of the shaft is much steeper then those more nort.	Well I felt like ar took away from the experience. Walking around and looking around with out haveing to look at your phone is	The mine has fallen apart. Shaft houses have been torn down.	Is there a way to explore the underground portion of the mine to compare against the other mines I have been in, like Quincy and adventure mine.	9	No

Yes	Overall, the experience of using AR synced with my anticipation of learning given that the tool was able to help me understand the buildings that I was in. I was able to see and learn about the buildings while exploring the area unguided. Overall, however, the AR tool was less conducive to my learning experience than a tour guide would have been. In general, I think I would have learned significantly more about the area and the buildings if we had toured the area in a guided fashion. In many ways, the AR application felt distracting to the experience. I often avoided using it once I was in an area to ensure that I could physically enjoy the space that I was in.	The most significant feature that I encountered on the site was the hoist house. I found the the control room in that building the most interesting physical item I was able to interact with as it made me better understand the working conditions a worker would have had in that era. The old newspaper clippings and photos strung around the control room made the place feel personal to a worker and attached a level of sediment to the site.	The AR application primarily acted as a tour guide for me in wondering around the site. I had difficultly in getting the information to display accurately and consistently, so I was unable to read much of the information the application provided. Additionally, clicking on each text box linked me back to the map instead of opening a separate dialog box; this was an error it sounded like a few other people had as well. Due to these reasons, the information I was able to get from the AR application only included general building layout and names. Using this information, however, I was able to traverse the site with a better understanding of how the buildings were laid out in the site and how they functioned together.	I was unable read about how the landscape changed over time in the AR application, but it sounded like significant work has been done to the site recently to conserve its place in history. Vegetation has been removed and buildings have been supported to keep them from collapsing.	One question that I had was about one of the taller diamond-topped buildings on the site. Upon peaking inside, we could only see a large metal cylinder. We believe that it was a boiler used to create steam power, but I would be curious to learn more. I might be able to answer these questions by researching the historical operation of the mine or talking to a historian/tour guide for the site.	8	Maybe
Yes	I learned more about the history of the mines	The electrical systems in the hoist building were really interesting	I used it for about 5 minutes then put my phone away and instead looked around and wandered without it. It did not impact how I interpreted the landscape much, if at all.	Rocks have moved, asphalt installed, stamp sands piled high	If I have any I will google them	5	Maybe
Yes	Learned a little bit more about the mine.	That cart in the shaft stood out to me. It was one of the places to see what the miners went into the mine in.	The points on the map were cool to see because you could then go to that location to see what is there and what could have been there.	Trees/vegetation growing, buildings decay, or something new could be built in that spot.	Don't have questions.	9	Yes
No	I think it would have been nice to get a guided tour of the site similar to the class trip to the smelter then give us time to use the ar app.	I was surprised with how the condition of the interior of the buildings was. Everything seemed to be well preserved and still in very good condition.	It gave some good information on what each building was but it would be cool if there was more information such as once you were in the building if there were pictures inside the app of the things you are looking at describing how they are used or what might be missing that was once there.	The rail tracks that would have the ore carts used to transport the rock from the mineshaft to where it would have been processed were in poor condition but you could tell what it use to be. Also the overgrowth of vegetation, I would assume that when the mine was actually in use there would have been very little vegetation on the site because it would just get in the way of production.	How deep is the mine shaft? How much copper was taken out of this mine? How many people worked here? All this information could probably be found online when searching the champion mine.	4	Maybe
Yes	It helped me to identify what exactly i was looking at and allowed me to get more history out of what was around me.	The cart inside the shaft house itself was really prominent in my head. It just seemed really massive and i could imagine piling men into it and sending it down into the mines.	It allowed me to see more history of what was around me and how it was possibly used back when the mine was open. This helped my imagination to try and see what life was like before.	Many of the buildings likely collapsed or were torn down after the mines shut down in order to gain some more money for the company. The fall of the company likely also contributed to the rust and disrepair many of the buildings today were left in.	Why did the mining company totally leave the area? i could most likely do more research into what led to the mines downfall and how it came to where it is today.	10	Yes
No	maybe I wasn't using the app right but I thought there would be more explanations or background to the labels provided in the app My GPS didn't work correctly so I had to use the manual controls which wasn't ideal	the app is very hard to navigate, it is annoying how you need to constantly need to re-sign in. GPS didn't work. manual controls aren't ideal	personally, I'm not sure if it did. I went to everywhere I would have gone without the app. and like I mentioned before I'm not sure if the information in the app provided any further details not seen in person I was nice that you could see what was far away though	Buildings became ran down. Trees overpopulated the area	None at this time. If I did have questions, I would use google or investigate some of the Michigan tech archived documents	7	Maybe
Yes	There was a lot of cool information scattered throughout the area that the AR helped give more insight into what happened there.	I was really intrigued by the book of causes of deaths at the mine. Not only were there a lot of different causes recorded, but it was surprising how long the list was.	It gave a lot of insight into what happened in the area and provided a sort of bonus information to what I was looking at.	Many trees would have been cut down to build the buildings, and then some more were cut down to create more space. Fast forward to today, the buildings are starting to fall apart and are needing reinforcement. Nature is starting to take back over some of the area as more brush has grown in over the years.	My biggest question would probably be how much different did the area look when the buildings were in operation. I could probably find some pictures somewhere online or in the library archives.	8	Yes
No	There was not as many "pop ups" as I thought there would be and it was difficult to view them.	The amount of stuff left behind.	It provided a rough direction of where points of interest were.	Over time the buildings started to crumble and fall apart until they were protected by the park service.	When did the mine close? Were there any expeditions into the mine after it closed? Looking the site up on the internet.	4	Yes
Yes	It was very cool. I have not been there in a long time and the app was very useful!	The mine cart for transporting men was pretty cool, and the gentleman there explained how the different carts worked.	The AR application was cool. For example, I had no idea what the one building was and the AR described what it was and what it was used for.	Well buildings have deteriorated and fallen down, trees have grown over areas, new buildings have been built.	Well I'd love to be able to go up to the top of the hoist and see how that works but the guy we talked to said they're working on making it safe so that is available.	10	Yes