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Interdisciplinary Perspectives on Virtual Place-Based Learning

Edited by
Reneta D. Lansiquot
Sean P. MacDonald

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CHAPTER 1

Situating Interdisciplinary Place-Based Learning as a High-Impact Educational Practice

Reneta D. Lansiquot and Sean P. MacDonald

Abstract Our introductory chapter explores how virtual place-based learning can be modeled in the context of urban higher education. It examines how the concept of virtual has been creatively interpreted across a range of disciplines including the sciences, humanities, behavioral sciences, and professional studies, with chapters that explore the many contexts for its application while drawing upon an interdisciplinary perspective. At the same time, the unique nature of this approach as illustrated in subsequent chapters is its application to courses that are already interdisciplinary. In this way, the chapter seeks to connect virtual place-based learning approaches to the concept of interdisciplinarity as an innovative approach to student engagement—an approach that firmly establishes virtual place-based learning as a high-impact educational practice.

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Keywords Data visualization • Digital storytelling • Game design • High-impact practice • Interdisciplinary virtual place-based learning • Mapping

Lansiquot and MacDonald's *Interdisciplinary Place-Based Learning in Urban Education* with faculty at the New York City College of Technology concluded with the chapter "Modeling Interdisciplinary Place-Based Learning in Virtual Worlds: Lessons Learned and Suggestions for the Future,"[1] which examined some ways in which the virtual can be used to enhance interdisciplinary place-based learning. This volume seeks to expand upon the concept of virtual place-based learning, with chapters that explore the many contexts for its interpretation and application in an urban learning environment. At the same time, the goal is to examine the integration of virtual place-based practices within the framework of interdisciplinary teaching in an undergraduate setting, highlighting both the interdisciplinary framework and the value of place-based learning in urban higher educational settings. The chapter contributions further highlight the evolution and development of place-based learning as a high-impact educational practice.[2]

We consider that learning in virtual worlds by definition is place-based; this includes game-based learning. Contributing authors consider how the concept of virtual has been interpreted in their teaching and how virtual space has been used to define "place" from an interdisciplinary perspective. They provide a comprehensive study of how this innovative pedagogical approach can be effectively implemented and provide a model for how its adoption at other institutions of higher education can further advance critical thinking and inquiry in new and innovative ways.

Virtual place-based learning, employing the tools of digital storytelling, mapping and data visualization, game design, and information literacy as methodologies, is explored as an approach that can both enhance the exploration of physical place and reimagine the physical in an interdisciplinary environment. In this context, this book focuses on the wide range of disciplines in which learning and student engagement and inquiry can be enhanced by virtual place-based learning, at the same time exploring how the cultural, technological, and discipline-focused contexts in which virtual techniques have been employed facilitate interdisciplinary knowledge.

We also consider how virtual place facilitates study in urban environments where physical observation and study are not possible, or where the virtual can *enhance* the study of physical space. At the same time, it considers how the resources of urban settings can be cultivated in designing virtual methodologies. In this way, the experience of place can be realized as geographic place, while other limitations of physical space are transcended.

Further explored is the question of how virtual place-based learning in urban higher education settings can serve the purpose of engaging a diverse student population with the real world. How can virtual locations be employed in interdisciplinary ways to realize the concept of place in such settings where access to the physical location isn't possible? How have the resources of urban spaces been used for this purpose?

This book examines the variety of resources faculty teams have used in interdisciplinary virtual place-based learning in response to the following questions: how has the concept of virtual been applied in your teaching and/or student projects? How has virtual space been employed to connect the interdisciplinary theme of a course to real-world experience? What activities have been undertaken? What were the processes, what were the outcomes, and how were the outcomes assessed?

The implementation of interdisciplinary virtual place-based learning detailed in these chapters may take the forms of web-, project-, or game-based learning environments. Through the interdisciplinary experience, students learn to identify and to discern the perspectives of different disciplines, to purposefully connect and integrate knowledge and skills across multiple disciplines to solve problems, and to synthesize and transfer knowledge across disciplinary boundaries. In the process, students become more flexible thinkers who are comfortable with complexity and uncertainty; understand other factors inherent in complex problems; grasp the universal nature and deep structure of science; prepare for their future as lifelong learners; and apply their capacity as integrative thinkers to solve problems in ethically and socially responsible ways.

Given this scope of outcomes related to interdisciplinary learning, we aim to connect virtual place-based learning to strategies for productive collaborative interdisciplinary studies at the college level. The focus on place-based learning complements interdisciplinary studies as place-based learning encompasses active project- or problem-based education.

There is an extensive body of literature that explores the ways in which learning can be enhanced through the employment of virtual strategies and that focuses on approaches to using specific technologies, such as game-based learning and geographic information systems (GIS) to augment teaching and learning. Other studies consider both the benefits and the challenges posed by educational technology centered on virtual tools.

Iqbal et al.[3] used a survey to highlight the many ways in which virtual contexts can be used as a means to engage students "in learning by doing." They pointed to a range of learning strategies that can be facilitated through virtual place-based learning, including project-based, experiential, and inquiry-based learning, as well as "interaction with and through avatars in a graphical, immersive, and embodied context [that] provides interesting possibilities for experiential learning and for exploration."[4] The authors further highlight the social and collaborative nature of virtual worlds, noting that they enhance communication and interaction among users "through the interaction of avatars with the artifacts in a virtual world."[5]

The benefits of employing computer-based simulations to complement traditional learning methodologies in the life sciences via virtual science labs are discussed in Zumbach et al.[6] The authors consider one such project, *Lifelab*, which includes a multidisciplinary approach to learning, drawing upon the expertise of faculty across disciplines, including information technology, psychology, pedagogy, and computer-based learning. The central goal of the *Lifelab* laboratory simulation is described as making "authentic life science research accessible to students and to support students (and teachers) in scientific reasoning and discourse."[7] The authors' evaluation of the simulation program concludes that it effectively engaged students at varying levels of preparation and that student learning was effective.

In another study Holden and Sykes[8] examined the effect of a place-based augmented reality context for language learning through students' use of the mobile game, *Mentira*, for learning Spanish. In this study, the classroom—or place—for language learning becomes the local community, supplemented by the virtual design of that community. Following one semester of participation, students overwhelmingly indicated that they felt highly engaged and experienced as active participants in the learning process. Students also offered suggestions for improving the game itself and several of its features for learning Spanish, which led to subsequent design modifications and revisions to narratives.

A number of sources have evaluated the benefits and challenges posed by educational technology such as virtual tools,[9] while others have explored the use of specific technologies such as game-based learning and GIS to augment teaching and learning.[10] Wu et al.[11] cited many benefits of virtual and augmented learning environments, including the ability of such approaches to close gaps between formal and informal learning processes, to enhance learning, provide an environment that "gives learners a sense of being in a place with others," and the ability to visualize the unobservable. Similarly, Jones et al.[12] conceived of virtual learning as a methodology that can address a variety of needs, are always accessible and that can be used and shaped by those who use them. However, many of these sources cite problems that can arise with some augmented learning environments, including as a lack of portability in some cases and requirements that students carry out complex tasks.

Lamb et al.[13] considered the benefits of geovisualization tools in teaching—GIS in combination with web-based technologies—in expanding the accessibility of geographic information and in using that information to create and enhance maps. Wharburton, evaluating the educational contributions of virtual world environments, identified the opportunities for enhanced social interaction, visualization of information, reproduction of potentially costly real-world learning contexts, and "opportunities for creation and ownership of the learning environment and objects within it."[14] At the same time, however, overcoming technical challenges and the need to carefully plan and develop social networking tools are among several potential barriers that can arise.[15]

In Saniye's study of student engagement with virtual worlds, the author examined the relationship between "place presence, social presence, and co-presence in virtual worlds"[16] and the level of student fulfillment in a virtual learning environment. The author found that all of these dimensions of "presences" were experienced by students in the virtual environment, and all were significant predictors of student satisfaction with that environment.[17]

Within this wide-ranging literature, however, the connection of virtual place-based learning approaches to the concept of interdisciplinarity as an innovative approach to student engagement is still largely unexplored. At the same time, while these examples attest to many of the benefits of virtual place-based learning across a range of disciplines and settings, the conceptualization of this methodology highlights some differences from the approach discussed in the current book. As a vital next step, we illustrate the benefits of incorporating the virtual into the study of place from an interdisciplinary perspective, highlighting the variety of ways it has been adapted across a range of courses, including the sciences, humanities, behavioral sciences, and professional studies. At the same time, we consider how these practices can be adapted in innovative ways in a classroom setting.

The extensive literature exploring the benefits of incorporating a virtual place-based approach in student research and learning attests to the value of this methodology. An important next step is to highlight the benefits of applying this methodology from an interdisciplinary perspective, highlighting the variety of ways it has been adapted across a range of disciplines within the sciences, humanities, behavioral sciences, and professional studies.

In “Virtual Place-Based Learning in Interdisciplinary Contexts: A Psychological Perspective and a Review,” Hillstrom examines the concept of virtual, exploring the meaning of presence in the context of teaching and learning. Following an overview of how “virtual” has been interpreted in the literature, she focuses on how virtual place-based learning has been applied, conducting a meta-analysis of the effectiveness of virtual reality (VR) educational methods that have involved adult learners, have included an experimental design, and have applied objective measures of student outcomes. The overall finding supports the conclusion that undergraduate students exposed to VR learning environments perform better than those who do not have this exposure. In the chapters that follow, the unique character of virtual place-based learning is highlighted through its varied application to courses that are already interdisciplinary.

Thus, in “Virtual Reality as a Pedagogical Tool for Interdisciplinarity and Place-Based Education,” Park begins by detailing her own work with place-based education and VR. Specifically, she outlines the collaborative student projects that create and engage with VR in her interdisciplinary *Weird Science* class, which explores the question of “what it means to be human.” She examines how the virtual supports students’ experiential learning as they collaborate on the development of a virtual world, which in every aspect reflects their view of what defines being human after having heard from several guest lecturers across a wide range of disciplines addressing a particular aspect of the human condition. Employing a phenomenological framework, she then highlights how the varied approaches to virtual exploration discussed in each of the book’s chapters have incorporated virtual exploration in creative and innovative ways.

Leonard explores the role of information literacy in an interdisciplinary learning environment where students are involved in searching, evaluating, and creating information. In interdisciplinary courses, such as *Language and Technology*, *Black New York*, and *Learning Places: Understanding the City*, Leonard’s discussion examines the benefits to student learning through the virtual access to information and digital archives, as well as through on-site visits to view special collections and archives at local libraries and museums. In her role as a guest lecturer in these same interdisciplinary classes, she further details the ways in which students are able, through their "virtual exploration of place," to interface with information, such as digital maps depicting the history of places and virtual museum visits that provide an online tour of archives where in-person observation is not accessible.

In "Visualization and Analysis of Environmental Data," MacDonald examines the employment of virtual place-based learning through data visualization in an interdisciplinary undergraduate environmental economics course. Beginning with an exploration of open data sources and continuing through the process of data selection, this visualization project seeks to engage students in the practice of interdisciplinary virtual place-based inquiry and research using *Carto*, an online mapping tool. This virtual learning from place takes students through the steps of data collection, including identification, filtering, designing, and creating a map, and then researching and discussing the environmental story behind the mapped data. After having heard from invited guest lecturers in disciplines ranging from sociology to psychology to architecture and hospitality, students work collaboratively in groups of two or three toward defining a subject area they want to investigate for the project, with the interdisciplinary perspective informing their inquiry. An important focus of the project at the same time is to facilitate students' increased awareness of environmental issues within the urban setting of New York City. In the process, they explore the relevant social, economic, and historical dimensions of the issue, fostering the development of a more comprehensive interdisciplinary perspective.

In their examination of the intersections between theater and architecture, Chin and Swift discuss how their application of a digital mapping program enables students in their interdisciplinary *History of Theatre* course. Digital mapping is viewed as a tool that effectively connects the humanities with the social and behavioral sciences, architecture, urban studies, geography, and other disciplines, readily facilitating the exploration of an interdisciplinary perspective. Students are initially engaged in on-site tours of local theaters and course content that explores the cultural and architectural history shaping theater development. The chapter emphasizes the importance of this interdisciplinary and historical context in students' development of GIS maps highlighting connections between cultural and architectural history that has shaped theater from the nineteenth century through the present.

Moysey and Lazar's chapter examines the benefits of VR to simulate field study in the earth sciences. The authors emphasize the notion that attention to "presence, interaction and accessibility" in designing a VR learning experience will more effectively simulate a real setting and enhance the learning process as students apply concepts learned in the classroom to a virtual experience. They examine how virtual field experiences can be made more interactive and accessible through the application of a variety of VR technologies, while at the same time offering a guide for how students can eventually begin to create their own VR material. Several of the activities outlined prompt students to make connections between geographically and geologically close and familiar places and more distant locations. At the same time, as students begin to use the VR experiences in the course to create and describe their own content and stories, their communication skills in the geosciences are enhanced.

Rosalia investigates the affordances and limitations of VR as a new medium for making audiences feel present and empathetic to a narrator's story. Using specific examples of recent journalism on the immigration crisis, she revisits old questions regarding voice, author's craft, and intended audiences. She argues for teaching our students how to critique and create non-fiction VR documentaries based on lived experiences, and understanding the process of filming with a 360-degree camera. This emphasis on self-directed engagement with the narrative has become prevalent in game narratives.

Artificial intelligence in video games has progressed to become so complex that narratives have become open-ended and players end up creating their own narratives. Lansiquot, Cunningham, and Cabo address this current state of game narratives as they explore the intersection of computational thinking and writing. They expand the discussion of interdisciplinary virtual place-based learning to include role-playing games and, simultaneously, make the case for game-based learning as a high-impact educational practice. With the research on game-based learning still emerging, this chapter offers a timely discussion of an educational practice that could have wide-ranging implications for teachers and students.

This book makes an important contribution to the literature on virtual place-based learning, focusing on how it has been designed and employed in creative ways across a range of disciplines. At the same time, it highlights how VR techniques have been designed to bridge the gap between virtual worlds and direct observation in real-world settings. It further offers a model for how the interdisciplinary approach can enhance virtual place-based learning as a high-impact educational practice, while offering a resource for college educators interested in incorporating an interdisciplinary approach in the design of virtual learning environments. In highlighting the work of faculty at both our and other institutions, this book serves as a valuable resource for how interdisciplinary virtual place-based learning can be applied broadly within institutions in urban settings.

NOTES

1. See Tamrah D. Cunningham and Reneta D. Lansiquot, "Modeling Interdisciplinary Place-Based Learning in Virtual Worlds," in *Interdisciplinary Place-Based Learning in Urban Education: Exploring Virtual Worlds*, eds. Reneta D. Lansiquot and Sean P. MacDonald (New York: Palgrave, 2018), 133–145.
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7. Zumbach, et al., "Learning Life Sciences: Design and Development of a Virtual Molecular Biology Learning Lab," 289.
8. Christopher Holden and Julie M. Sykes, "Leveraging Mobile Games for Place-based Language Learning," *International Journal of Game-Based Learning* 1 no. 2 (2011): 1–18.
9. See Matt Dunleavy, Chris Dede, and Rebecca Mitchell, "Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning," *Journal of Science Education and Technology* 18, no. 1 (2009): 7–22; Hsin-Kai Wu, et al., "Current Status, Opportunities and Challenges of Augmented Reality in Education," *Computers and Education* 62 (2013): 41–49.
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16. Tugba Bulu Saniye, "Place Presence, Social Presence, Co-presence, and Satisfaction in Virtual Worlds," *Computers & Education,* 58 (2012): 159.
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CHAPTER 2

Virtual Place-Based Learning in Interdisciplinary Contexts: A Psychological Perspective and a Meta-analytic Review

Jean E. Hillstrom

Abstract This chapter briefly explores the meaning of “virtual” and the psychological concepts of presence and immersion followed by the application of virtual reality (VR) methods in post-secondary education. A meta-analysis was conducted to determine the efficacy of VR compared to more traditional teaching methods. Overall, students who experienced VR significantly outperformed those experiencing more traditional methods by about three-quarters of a standard deviation. These results were moderated by immersiveness (students in moderately immersive environments outperformed those in low or high immersive environments), whether place-based pedagogies were incorporated (students experiencing place-based VR pedagogies performed better), and student level (undergraduate students in VR conditions performed better than those in traditional

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classes). It is concluded that VR pedagogical methods, particularly when moderately immersive and place-based, benefit undergraduate students the most.

Keywords Education • Efficacy • Meta-analysis • Virtual reality

This chapter explores the meaning of presence and emotional and behavioral responses in a virtual environment from a psychological perspective and applied to interdisciplinary place-based learning. In thinking about "virtual" in the context of learning, teaching, and education, one encounters a myriad of terms and labels such as virtual learning environment (VLE), augmented reality (AR), and virtual reality (VR). While analyzing and tracing definitions of these terms is not the focus of this chapter, it will be helpful to briefly survey how they are used in the literature.

Dillenbourg, Schneider, and Synteta characterized a virtual learning environment as being a purposively designed information space that is social (i.e., there is interaction in the space), explicitly represented (e.g., a virtual museum), and "co-constructed" where students and teachers can affect and be affected by the space.[1] Other authors have noted the wide range of interpretations of VLEs in the literature which vary from websites instructors created for their students to course management systems such as *Blackboard* and *Moodle* to massive open online courses (MOOCs) to courses offered in desktop three-dimensional (3D) worlds such as *Second Life*.[2] These variants typically contain course documents, opportunities for interactions (e.g., chat room, email), and so forth.

Another term, augmented reality (AR), was first used by Caudell and Mizell[3] in reference to a "heads-up, see-through, head-mounted display" that was designed to be used by factory workers to "augment the visual field of the user."[4] In an important paper (SCOPUS citations were 478 in August 2019), Wu and colleagues[5] characterized augmented reality (AR) as a "bridge" between virtual and real worlds where technology is used to enhance or augment real-world places or situations. In their discussion, they described AR in terms of its features and affordances. For example, they noted that AR can enable visualization of content (such as a solar system) traditionally presented in 2D (e.g., photos) and/or in physical form (e.g., models) in virtual 3D form. Similarly, AR can be used to present content in virtual worlds and "games." An example of a place-based[6] augmented reality used in education is presented by Klopfer and Sheldon.[7]

They described a game called TimeLab 2100 where students can assume roles in the Massachusetts Institute of Technology TimeLab in a future where climate change is occurring. Students visit various actual physical locations on the campus and can discover, using hand-held devices or cell phones with GPS, what the area looks like in the future. For example, in one area, the sidewalk near a river is underwater in 2100 and students can discuss and generate possible solutions. Wu and colleagues[8] and others[9] additionally note that AR can make use of a variety of technologies ranging from high-tech head-mounted displays (HMD) to cell phones with GPS to remote laboratories.

Given the above characterizations of VLEs and AR, for the purposes of this chapter, the term virtual reality (VR) will refer to computer-technology that is used to create simulated, three-dimensional (3D) environments. These environments can represent real places (e.g., the Louvre in *Second Life*; an airplane cockpit simulator) as well as imaginary or fantasy worlds where the user can manipulate and explore while feeling as if they were in that world (immersive VR). (The uses described in the previous paragraph would be considered VR for this chapter.) An example of VR I have used in my Introduction to Psychology classes is Sniffy the Virtual Rat.[10] Sniffy is a 3D computer program that was created to teach principles of learning using a virtual rat in a virtual Skinner box. As an undergraduate, I had the experience of shaping live rats in a Skinner box and training them to do various actions using operant conditioning techniques.[11] I was duly impressed by how well the Sniffy software simulated the experience of training live rats, and I often smile when my own students remark on how frustrating it is to train their "rat" or that their "rat" just cannot learn to press a bar. Elcoro and Trundle's[12] study of student preferences parallels my students' impressions of Sniffy. They found that although their students preferred working with the live rat, those students felt that Sniffy adequately represented the behaviors of a live rat. With regards to efficacy, Lewis[13] and other researchers[14] have found support for using a virtual rat to teach learning principles.[15]

The effectiveness of a virtual environment as parallel to real environments is commonly determined by the psychological concept of "presence." Early on, Slater and Wilbur described virtual environments in terms of immersiveness and presence.[16] They suggested that immersion can be objectively and quantitatively measured in terms of how successfully a VR system can "deliver an inclusive, extensive, surrounding, and vivid illusion of virtual environment." In addition, they noted that immersiveness also varies based on the "the extent of body matching" and whether there is a "self-contained plot" that the participant can become engaged with. In this same article, Slater and Wilbur characterized presence as one's psychological feeling of "being in the virtual environment" and noted that participants can subjectively evaluate their sense of being "there." In addition, participant behaviors can be objectively assessed.[17] The authors inferred that presence is integral to fostering behaviors in a virtual environment similar to those that would occur in the real world. In applications to training or education, presence would then be essential for learning and transfer of information and skills. In sum, Slater and Wilbur considered immersion to be a fundamental component of psychological and behavioral presence.[18]

Likely the first experimental study of immersiveness and presence was conducted by Hodges and colleagues in 1995.[19] They designed several virtual environments to evoke emotional and physical responses such as fear as a necessary component of providing treatment for acrophobia (fear of heights). Three virtual scenarios were developed: bridges, balconies, and an open elevator which were presented using an HMD. They recruited a sample of 20 college students with probable acrophobia to assess the effectiveness of using virtual environments with graded exposure therapy to reduce their phobia. Half of the sample was exposed to the virtual environments in a graduated manner (less to more stressful) and the other half served as the comparison group. At each level, participants in the VR condition were given time to habituate to the particular height situation (e.g., balcony on a first floor) before moving to the next situation (e.g., a balcony on a second floor). The authors used several measures of presence: number and type of physical symptoms of anxiety (e.g., sweating, shakiness, nervousness), anxiety ratings during exposure to the environments, and therapeutic effects (e.g., decrease in expressed fear). Results showed that participants in the VR condition reported anxiety symptoms which the authors took as evidence of presence. Similarly, anxiety ratings were elevated for initial exposures to the various height situations and decreased with exposure over time (as expected). Importantly, before and after ratings of anxiety, avoidance, distress, and scores on the attitudes toward height questionnaire significantly improved for the treatment group but not the comparison group. The authors concluded that VR exposure therapy was just as effective as the more traditional therapy for acrophobia and these results would not have occurred unless the participants were "present" in the virtual environment. Last, with regards to immersion, the authors noted that most subjects “appeared to become immersed”[20] citing behaviors such as grasping for railings.

Nearly ten years later, researchers were still discussing “presence” and the lack of consensus on what exactly it is, and what factors affect it. Bouchard and colleagues[21] investigated the relationship between anxiety and presence in order to determine the direction of the relationship in a sample of 31 participants with a snake phobia. They found that inducing anxiety appears to lead to a greater sense of presence in the virtual environment. Reiner and Hecht studied presence in a computer-generated haptic virtual environment that allowed participants to see and touch (with a stylus) a set of parallel lines or the same set of lines presented as a virtual razor with blades.[22] They found that participants moved the stylus more slowly and with less pressure over the virtual razor blade versus the parallel lines and concluded that presence can occur in a non-immersive virtual environment. It should be noted that the authors viewed immersion slightly differently than Slater and Wilbur.[23] They characterized immersive virtual environments as a “sense of being and acting inside a virtual place” as compared to a haptic virtual environment which is non-immersive but presence could be obtained when the participant has a “sense of being able to touch and manipulate a virtual object.”[24] Both groups of researchers appeared to view immersion as a function of the technologies employed in creating/rendering the virtual environment but Reiner and Hecht did not include the concepts of body matching or plot. It appears that the concept of immersion here has evolved to refer primarily to the affordances VR technologies can provide.[25]

The second section of this chapter focuses on the application of virtual realities in the context of adult education and learning. Several literature reviews have been conducted in this general area, for example, Bujak and colleagues’ review[26] of augmented reality in the math classroom, Hew and Chung’s review[27] of how 3D immersive virtual worlds are used in educational settings, Kurilovas’ review[28] of the quality of educational VR systems, and Mikropoulos and Natsis’ review[29] of the effectiveness of desktop-based VR environments on learning in K-12 and higher education. Implicit in these studies and reviews are questions regarding efficacy of VR versus more traditional educational approaches (e.g., lecture format) in the classroom. VR in educational settings has received a fair amount of attention, particularly in the past ten years or so. Dillenbourg, Schneider, and Synteta[30] conducted perhaps one of the earliest reviews where they explored and delineated the concept of virtual learning environments as a purposeful space with varied technological affordances ranging from text to 3D immersive worlds where participants are active and “co-construct”[31] the space. They explored pedagogy in these virtual learning environments and noted that the technologies themselves do not guarantee efficacy or learning but rather, this is up to the designers and instructors. Additional reviews of a general nature were identified including Martirosov and Kopecek[32] who summarized the literature and presented advantages and disadvantages of the use of VR in training and education. Hansen[33] explored the use of virtual worlds and VR gaming in healthcare education. She presented examples, discussed pedagogical theory (e.g., connectivism—proposes learning is a creation of internal and external networks), and identified challenges and benefits of using VR in health care education.

Traditional qualitative or narrative reviews serve important functions in summarizing a body of research but also suffer from inherent challenges: how does one summarize a large body of research? If selecting a smaller number of studies, how does one decide which to include in the review? How does the author deal with conflicting research results? One simple quantitative approach is the vote-count method where all studies pertaining to the research question are gathered and the number of studies with significantly positive, negative, or neutral results is counted. The category with the highest count is presumed to reflect the true relationship.[34] Maertens and colleagues[35] synthesized the e-learning literature for surgical training using the vote-count method. They conducted a systematic literature search using specified criteria (e.g., for a study to be included, the e-learning group must be compared to a control or standard group) and sorted by study characteristics (e.g., type of e-learning platform). Results were tabulated as to whether the e-learning group performed statistically better than, the same as, or worse than the comparison group. The authors concluded that those in e-learning groups learned more, or as much as those in more traditional learning environments (e.g., a classroom), or received no training (i.e., control groups).

As one can imagine, there are a number of problems with vote-count methods. How does one account for studies of varying sample sizes? What about statistical power or treatment differences (e.g., the educational intervention)? Meta-analytic techniques were developed to help address these issues when performing systematic quantitative reviews.[36] As with qualitative reviews and vote-count methods, meta-analyses are conducted when there are a number of studies on a topic and one wishes to summarize across studies more precisely, address inconsistencies in a literature, or make generalizations. The general process involves gathering all studies relevant to a research question, and then identifying or calculating an effect size that represents the relationship under investigation from each study. These effect sizes are used to compute statistics to summarize the data across studies. The only meta-analysis to date on effectiveness of VR games, simulations, or virtual worlds on various learning outcomes was conducted by Merchant and colleagues.[37] They found that, in general, VR games resulted in greater learning across student ages and across type of learning outcome. However, there do not appear to be any meta-analyses assessing the efficacy of virtual place-based learning in adult learners (post-secondary, college students) in the extant literature.

2.1 A Meta-analysis of the Efficacy of VR Versus Traditional Pedagogical Methods

To address limitations of the aforementioned studies, and of qualitative reviews on this topic in general, a meta-analysis was conducted to determine the educational efficacy of VR compared to more traditional pedagogical approaches. The Schmidt-Hunter psychometric methods provide an estimate of the true average effect size (i.e., the true relationship) across studies by calculating the variance attributable to artifacts (e.g., sampling error) and subtracting that amount from the total amount of variation. This results in an estimate of the true variation across studies and of the true average effect size.[38] These methods address sources of artifactual error including sampling error, measurement unreliability, and range restriction (where applicable) and also allow for testing of moderators by using subset analyses.[39] The Hunter-Schmidt Meta-Analysis Program (version 2.0) derived from Schmidt and Hunter's methods was used.[40] After the data were collected and examined for potential outliers (no outliers were found), a Type 4 meta-analysis of d effect sizes was conducted since only partial artifact information was available in some studies. The artifact distribution for reliability of the dependent variable was constructed using data from those studies reporting the requisite information.

A two-step procedure was used to identify potential sources of data. First, comprehensive key word searches were conducted in relevant databases: Academic Search Complete, Applied Science & Technology Source, Avery Index to Architectural Periodicals, Business Source Complete, Library, Information Science & Technology Abstracts, Communication & Mass Media Complete, EconLit, Education Source, ERIC, General

Science Full, Health Source: Nursing/Academic Edition, Hospitality & Tourism Complete, Humanities Source, PsycINFO, Social Sciences Full Text, Social Sciences Index Retrospective: 1907–1983, SocINDEX with Full Text, Teacher Reference Center, CINAHL Complete, MEDLINE Complete, and OpenDissertations. The key words used were virtual reality, augmented reality, virtual learning, education, learning, teaching, outcomes, and efficacy as well as meta-analysis and review, in combination. Search results were limited to those available in the English language. Second, references of previous literature reviews, meta-analyses, and other summary articles were examined for potential data.[41]

Studies were included in the meta-analysis[42] if they met the following decision criteria. First, selection of studies was limited to adult learners in college or similar settings (e.g., college students; post-secondary students) given the topic of this volume. Studies employing general populations were excluded (e.g., Butavicius, Vozzo, Braithwaite, and Galanis' study[43] of VR parachute training with Australian Army trainees). Second, studies were included if they used an experimental or quasi-experimental design that compared a treatment group (i.e., received instruction using VR technology) to a comparable control group (e.g., traditional lecture). For example, Persky and colleagues' study[44] was excluded because they compared learning using two different types of virtual learning environments but no control group. Third, only studies reporting objective learning outcome measures (e.g., test score, time to complete a task, performance rating by experts) were included. Two studies reported immediate and delayed post-tests. In these cases, only the immediate post-tests were analyzed since there were not enough studies with delayed post-tests to examine as a potential moderator variable.[45] Studies that reported perceived learning,[46] self-efficacy,[47] preferences,[48] or concepts unrelated to learning outcomes such as civic engagement[49] were excluded. Fourth, studies were included only if a d effect size could be calculated. Studies that did not report the statistics necessary for calculating a d statistic were not used. For example, Vergara, Rubio, and Lorenzo[50] did not include the sample size of the previous year's cohort; Lewis[51] reported a total sample size but not the sample size for each group; and Gunn and colleagues[52] reported means but not the standard deviations for each group. Twenty-nine studies with 33 effect sizes were identified that met the criteria and were included in the meta-analysis.

If studies reported more than one learning outcome measure (e.g., test score and time to complete a task), both outcome measures were recorded and a composite measure was created.[53] Studies sometimes reported more than one effect size for a particular type of outcome measure (e.g., two test scores). For example, Urhahne and colleagues[54] reported conceptual and factual posttest scores. In these cases, the effect sizes were averaged into a single effect size.

Standardized mean difference (*d*) statistics were cumulated. Direction (signs) of the *d* statistics were assigned so that positive indicated higher values in the direction of the experimental group (i.e., the group that experienced VR). Other statistics such as *F* (2-group), *t*, and so forth were converted into *d* using commonly available formulas.[55]

Potential moderators were coded by the author and included: degree of immersiveness of the VR technology, whether the VR group included a place-based component, whether the pedagogical methods used incorporated interdisciplinary teaching/learning or not,[56] and whether the students were undergraduate or graduate students. Moderator analyses were performed using subgroup analyses,[57] where there was a sufficient number of effect sizes (at least three) for each subgroup analysis.[58]

2.2 META-ANALYSIS RESULTS

Table 2.1 presents the results of the meta-analysis. The first two columns show the total sample size (N) and the number of *d* effect sizes on which each distribution was based. The next two columns present the sample-size weighted mean *d* effect size and standard deviation (SD*d*) of the observed distribution after removing sampling error variance. The last four columns present data on the estimated population distribution after correcting for unreliability in the dependent variable: the mean (Mean δ) and standard deviation (SDδ) of the population distribution, and the lower and upper bounds of the 95 percent confidence interval. If the confidence interval contains the null value (typically zero), then there is not a statistically significant difference between groups.[59] A discussion of the population values follows. Thirty-three *d* effect sizes with 4355 observations entered into the analysis of learning outcome differences between VR and more traditional pedagogical methods (see Table 2.1). The estimated population mean difference was

Table 2.1 Overall meta-analysis results

Total N	*# of* ds	*Mean* d	*SD*d	*Mean* δ	*SD*δ	*Confidence interval*	
4355	33	0.651	1.217	0.740	1.368	0.268	1.213

Table 2.2 Moderator analyses

	Total N	*# of* ds	*Mean* d	*SD*d	*Mean* δ	*SD*δ	*Confidence interval*	
Immersiveness								
Low	1753	18	0.334	1.728	0.380	1.952	−0.529	1.288
Medium	2348	10	0.965	0.508	1.097	0.549	0.739	1.455
High	229	4	−0.063	0.584	−0.072	0.592	−0.723	0.579
Place-based versus not place-based								
Place-based	2313	10	0.767	0.162	0.872	0.069	0.758	0.986
Not	2042	23	0.520	1.760	0.591	1.987	−0.227	1.410
Undergraduate versus graduate students								
Undergraduate	3125	25	0.790	0.537	0.898	0.568	0.659	1.138
Graduate	1150	7	0.321	2.153	0.365	2.443	−1.450	2.179

0.740 indicating that students who experienced VR pedagogy methods performed significantly better (about three-quarters of a standard deviation higher[60]) than students taught by more traditional methods.

Table 2.2 presents the moderator subgroup analyses and confidence intervals for degree of immersiveness, whether the study was virtual place-based (or not), and whether the students were undergraduate or graduate students. (There was insufficient data to conduct moderator analyses for the interdisciplinary variable.) Immersiveness was coded as follows: a score of "1" (lowest degree of immersiveness) was assigned to studies employing a 3D desktop VR program such as *Second Life* or a 3D simulation or similar; a "2" (medium) for a desktop 3D system with haptic or similar features; a "3" (high) included programs displayed using an HMD. There were not enough studies that used an HMD with a haptic (or similar) device or a cave automatic virtual environment (CAVE) system[61] to be included in this moderator analysis. Learning outcome differences between VR and more traditional pedagogical methods was moderated by immersiveness. There was no significant difference between students taught by VR versus more traditional methods when immersiveness was low (Mean δ = 0.380). However, there was a significant difference when the VR system was moderately immersive (Mean δ = 1.097); students performed more than a standard deviation higher. Interestingly, and contrary to expectations, there was no difference between pedagogical methods when immersiveness was high (Mean δ = −0.072). It should be noted that this effect size was based on only four studies which can affect population effect size mean and variance estimates.[62]

The moderator analysis for whether learning was place-based or not presented in Table 2.2 indicates that VR methods had a significant impact on learning outcomes for studies that used virtual place-based methods (Mean $\delta = 0.872$) compared to those that did not (Mean $\delta = 0.591$). Learning outcome differences between VR and more traditional pedagogical methods was also moderated by whether the sample was comprised of undergraduate or graduate students (see Table 2.2). (One study[63] was excluded because it did not separate learning outcomes by student level.) The estimated population mean difference for undergraduate students taught by VR versus more traditional methods was 0.898 and this difference was significant. Undergraduate students experiencing VR methodologies performed better than those taught by more traditional methods. However, for graduate students, this was not the case; the mean difference was much lower (Mean $\delta = 0.365$) and was not significant.

2.3 Conclusion

The goal of this chapter was to present a discussion of what is meant by "virtual" in the literature and a definition of virtual reality was derived and applied. The impact of immersiveness and presence on psychological and behavioral variables was explored, followed by a meta-analysis to determine the efficacy of VR technologies on learning. The meta-analytic results indicate that students who experience VR pedagogies perform better than those who do not. Several moderators were identified. Students who experienced moderately immersive VR conditions performed better than those in low or high immersive conditions. Students performed better when the VR pedagogies also employed place-based pedagogical experiences. Last, VR pedagogies had a significant impact on learning for undergraduate but not graduate students. It is clear that VR pedagogical methods, particularly when moderately immersive and place-based, benefit undergraduate students the most.

Notes

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3. Thomas P. Caudell and David Mizell, "Augmented Reality: An Application of Heads-up Display Technology to Manual Manufacturing Processes," in Proceedings of the *Hawaii international conference on system sciences* (1992): 659.
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5. Hsin-Kai Wu, Silvia Wen-Yu Lee, Hsin-Yi Chang, and Jyh-Chong Liang, "Current status, Opportunities and Challenges of Augmented Reality in Education," *Computers & Education* 62, (2013): 41–49.
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9. See for example: Murat Akçayır and Gökçe Akçayır, "Advantages and Challenges Associated with Augmented Reality for Education: A Systematic Review of the Literature," *Educational Research Review* 20 (February 2017): 1–11; Laura Freina and Michela Ott, "A Literature Review on Immersive Virtual Reality in Education: State of the Art and Perspectives," *eLearning & Software for Education* no. 1 (January 2015): 133–41; Eric Klopfer and Kurt Squire, "Environmental Detectives—the Development of an Augmented Reality Platform for Environmental Simulations," *Educational Technology Research & Development* 56, no. 2 (April 2008): 203–28.

10. Jeff Graham, Tom Alloway, and Lester Krames. "Sniffy, the Virtual Rat: Simulated Operant Conditioning," *Behavior Research Methods, Instruments, & Computers* 26 (1994): 134–141.
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14. For example, Sandy S. Venneman and Laura Ruth Knowles, "Sniffing Out Efficacy: Sniffy Lite, a Virtual Animal Lab," *Teaching of Psychology* 32, no. 1 (Winter 2005): 66–68.
15. I have not collected outcome data.
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17. Slater and Wilbur, "A Framework for Immersive Virtual Environments (FIVE)."
18. Slater and Wilbur, "A Framework for Immersive Virtual Environments (FIVE)."
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24. Slater and Wilbur, "A Framework for Immersive Virtual Environments (FIVE)."
25. Slater and Wilbur, "A Framework for Immersive Virtual Environments (FIVE)."

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38. See John E. Hunter and Frank L. Schmidt. *Methods of Meta-analysis: Correcting Error and Bias in Research Findings* (Newbury Park, California: Sage, 1990); Frank L. Schmidt and John E. Hunter, *Methods of Meta-analysis: Correcting Error and Bias in Research Findings.*
39. Frank L. Schmidt and John E. Hunter, *Methods of Meta-analysis: Correcting Error and Bias in Research Findings.*
40. Frank L. Schmidt and John E. Hunter, *Methods of Meta-analysis: Correcting Error and Bias in Research Findings.*
41. For example, Reza Ghanbarzadeh and Amir Hossein Ghapanchi, "Investigating Various Application Areas of Three-dimensional Virtual Worlds for Higher Education," *British Journal of Educational Technology* 49, no. 3 (May 2018): 370–84; Reza Ghanbarzadeh, et al., "A Decade of Research on the Use of Three-Dimensional Virtual Worlds in Health Care: A Systematic Literature Review," *Journal of Medical Internet Research* 16, no. 2 (February 18, 2014): e47; Khe Foon Hew and Wing Sum Cheung. "Use of Three-Dimensional (3-D) Immersive Virtual Worlds in K-12 and Higher Education Settings: A Review of the Research," *British Journal of Educational Technology* 41, no. 1 (January 2010): 33–55; Zahira Merchant, et al., "Effectiveness of Virtual Reality-Based Instruction on Students' Learning Outcomes in K-12 and Higher Education: A Meta-Analysis," *Computers & Education* 70 (January 2014): 29–40; Tassos A. Mikropoulos and Antonis Natsis, "Educational Virtual Environments: A Ten-Year Review of Empirical Research (1999–2009)."
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58. Although studies were coded as to whether they included interdisciplinary teaching or learning, there were not a sufficient number to include this variable as a moderator.
59. See, for example, Harris M. Cooper and Larry V. Hedges, *The Handbook of Research Synthesis* (New York: Russell Sage Foundation, 1994).
60. Laurence G. Grimm and Paul R. Yarnold *Reading and Understanding Multivariate Statistics*, eds. Laurence G. Grimm and Paul R. Yarnold (Washington, DC: American Psychological Association, 1995).
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CHAPTER 3

Virtual Reality as a Pedagogical Tool for Interdisciplinarity and Place-Based Education

Laureen Park

Abstract Place-based education (PBE) has long been recognized as a high-impact educational practice. It embeds learning in a multi-sensory context that nurtures active, praxis-driven, interdisciplinary, and collaborative learning. More recently, educators have begun to utilize digital media and virtual reality technologies in ways that seem to parallel PBE. Using phenomenological concepts, especially following Edmund Husserl and Alfred Schütz, this chapter explores what the parallels and differences might be between physical and virtual places, ontologically as well as in its pedagogical role in PBE. It also attempts to interpret the other chapters of the book in light of the philosophical implications.

Keywords Constructivism • Husserl • Ontology • Phenomenology • Place-based education • Virtual reality

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In this chapter, I will be using the philosophical perspective to anticipate and situate some of the themes in the book in terms of the role virtual reality (VR) plays in place-based educational (PBE) practices. Traditional PBE which renders "place" in physical terms will serve as a contrast. VR can be, and often is, used to mimic physical spaces—one can perceive, interact with, and navigate through a VR setting that is created to resemble a physical place. However, VR has unique features which go beyond physical-based PBE that I think should be exploited in their own right, even if these features fall short on realism compared to the physical world. VR's lack of realism can be taken as its virtue—it is created, can be deleted, modified, and tailored to suit the user's needs. These features give it a functionality for pedagogical purposes that is not possible in the "real" realm.

In this chapter, I will elaborate and describe recent scholarly reflections about what kind of a "being" VR is, accentuating its unique ontology as compared to the physical. I will then apply these reflections to the ways in which the authors in this book utilize VR in their own curricula. All of the authors use a range of digital tools in promoting the successful acquisition of learning outcomes that reflect the distinctive manner in which virtual media and tools support learning. These virtual media function as a concrete context that supports praxis-based, active, and collaborative learning which are the desirable outcomes of PBE. My focus will be the chapters that most exemplify a phenomenological approach.

To give a brief overview of the chapters in this book, in Stephen Moysey's and Kelly Best Lazar's, Sean MacDonald's, as well as Ting Chin's and Christopher Swift's chapters, virtual maps representing physical geological sites, environmental data, and community make-up, respectively, provide sensory cues that help students in the construction of concepts. They help students to think through the implications of economic and geographical data, as well as data about the community that influence the design of actual physical places. In Moysey and Lazar's chapter, photosphere and Oculus are also used to enhance the experience of replicated field sites, like the Grand Canyon. Christine Rosalia's and Jean Hillstrom's chapters highlight the efficacy of VR in promoting objectives that are psychological, which frames environments and realism in ways that are very different than how their topics are traditionally studied, such as studying external facts and statistics about immigration. They focus on the internal, subjective responses that are elicited by virtual environments and contexts, and demonstrate the efficacy of VR as a substitute for real ones. In Reneta Lansiquot, Tamara Cunningham, and Candido Cabo's chapter, gaming provides a figurative yet concrete world which students aim to build by coding collaboratively. There is an objective set of rules that govern the work and guides problem-solving with clear objectives. And in Anne Leonard's chapter, the physical places that house archival material and the wealth of text-based virtual resources mediating the understanding of historical places helps to provide a bridge between physical places and their historical meaning. Following Ossi Ollinaho, I use the term "province of meaning" to refer to the way VR environments frame learning which arises out of but is bracketed from the "paramount reality" (everyday reality).[1] Whichever predominates in the center of our attention and concerns is the "zone of primary relevance." The idea of a "province of meaning" highlights the fact that a given VR inculcates in students distinctive underlying theses and a horizon of rules, game play, objects, and avatars, which may not be physical, but nonetheless objective (users can interact and collaborate with and around them, whereas a hallucination or illusion, by contrast, is a private, ephemeral phenomena).

The theoretical framework I utilize in discussing these topics is informed primarily by phenomenology. I believe that it is particularly helpful in understanding the unique learning acquisition process of PBE with its accompanying interdisciplinarity, both in terms of epistemology and pedagogical solutions. In discussing the approach, I will be mapping phenomenological concepts to parallel ideas in constructivism. In analyzing the use of VR as a "province of meaning" in the chapters that follow in this volume, I would like to focus in particular on the metrics of abstraction and specialization as a way of assessing the efficacy of VR in addition to more general cognitive skills. Of the many learning outcomes that a study of pedagogy could focus on, these two outcomes regard the breadth and depth of discipline-specific content knowledge which are key metrics in academic learning.[2]

3.1 The Phenomenological Approach and Constructivism

It is no coincidence that much of recent scholarship analyzing the ontological status of VR draws from phenomenology. First and foremost, I believe that phenomenology truly reflects the relationship between self and world, which in many ways is true of how we relate to VR. But it also has the added benefit of articulating the relationship in a way that provides the structural components requisite to understanding how we interact with VR in its unique features as well. In a previous work, I articulated the many facets involved in this structure through reconstructing Husserl's epistemology as found in his *Ideas I* and *II*.[3] Let me provide a brief synopsis here of the relevant concepts.

Like all phenomenologists, Husserl believed that anything of the external world that enters into perception and cognition must of necessity conform to the conditions of that consciousness. To take a very simple example, humans and dogs have very different perceptual conditions—humans see a much greater range of colors than dogs, while dogs have a much greater range of smell perception. It would be fair to say that we are literally absent of the rich, varied realities of smell that is taken for granted by dogs. These differing conditions of perception, not to mention intellectual differences, affect how we see reality, as well as how we understand, analyze, and in other ways cognitively engage in the world. Recent scientific research by evolutionary psychologist, Donald Hoffman, explains that these differences in how we perceive the world evolved to aid survival and reproduction. As such, our perception is not at all concerned for a faithful depiction of the actual things themselves.[4] His work, as well as the work of a growing number of scientists,[5] refutes the anti-constructivist notion that the mind simply mirrors or passively reflects the external, unmediated thing. Husserl would agree with the idea that our reality is based as much on *how* we perceive as *what* we perceive, but this by no means implies that we cannot achieve objective knowledge.

In British and American philosophy, science is often defined by the formalistic, positivistic approach of analytic philosophy which seeks to equate empirical validity with things themselves and seeks to sever it from the realm of the mental and conventional. But as Thomas Kuhn wrote decades after Husserl in his famous work, *The Structure of Scientific Revolutions*, the paradigms of science are matters of convention as much as they seek to explain the physical universe.[6] Science is governed by norms, is tested by observation and experiment, which should be capable of being repeated by other scientists and are able to hold up to their critiques. This process ensures that the hypotheses of science, despite being merely "mental" stuff, maintain a standard of objectivity. I believe that the constructive process of learning is no different from this process. Students start with schemas that they acquire through their interactions in the life-world (paramount reality) and school, and bring those to bear when learning novel content. Through a process of testing and feedback from others, they become acculturated into the norms of any given discipline.

There is no one standard for all disciplines; each have shared assumptions and premises that govern what is acceptable or "true."

To get back to the phenomenological approach of Husserl's, let me reiterate a few key points as it relates to his constructive epistemology and learning. For Husserl, the transcendent object or the object prior to entering perception is not the object of our cognitions. By definition, we can only know an object once it enters into the sphere of consciousness. The way we perceive or know an object or idea is conditioned by the full array and complexity that make up a consciousness, including perceptual, social, psychological, and experiential considerations. But all perception has the basic structure of having a *noetic* component and a *noematic* component. Whatever exists in the "real" world exerts itself upon the mind as a thought-thing (*noema*) that is construed by the meaning-endowing processes of *noesis*. Husserl envisioned consciousness as a flashlight that has a ground zero (the fixed point at which the light begins) which emanates out to light an external world of things. The dark thing is the transcendent object; the lit thing is the *noematic* object. Consciousness has many rays by which it lights things, and these rays endow significations and meanings to what it lights as a constituent aspect of its very reality.[7] In Husserl's approach, our theses and meaning-endowing consciousness constructs perceptions and concepts as we acquire (construct) them, but he would also remind us that these cognitions are not entirely "subjective" as it is conditioned by heterogenic external physical and intersubjective realities that impose themselves upon our consciousness and resists it. This militates against a relativistic or solipsistic construal of the phenomenological approach.[8]

3.2 The Ontology of VR According to Phenomenology

This description of the way in which we perceive things in the external world also speaks to how we perceive VR for the obvious reason that VR is now a part of our lifeworld and we can have perceptual experiences of it. Though VR is coded and therefore a *made* reality, once it has been created, it can be perceived, and interacted with. Some scholars, like Ossi Ollinaho in "Virtualization of the Lifeworld," go further and point out that the digital world has shaped our everyday world in significant ways.[9] There are more complexities to the ontology of digital realities than its ability to mimic physical environments and objects, but let me begin with discussing the obvious (perhaps) comparisons between VR and physical reality. I think this comparison is tempting because the expectation is set up by life experiences, as well as traditional PBE theories that the field experience of VR be *like* its physical counterpart. This is evident in some of the chapters contained here. Most often, what we notice is how VR fails to truly capture the full, rich experience that a physical context provides. Nonetheless, virtual PBE that aims to mimic the traditional PBE experience does still provide some of the same pedagogical benefits—it provides opportunities for students to be able to analyze and apply abstract concepts learned in books and the classroom to real-life context-based, concrete situations and problems.

Importantly, however, I think the ways in which the instructors in this book have utilized VR environments and tools demonstrate that VR has unique features that support learning outcomes in a way that also go beyond the parameters of traditional PBE. One key feature of VR is that its very existence is enabled through user participation and interaction, and therefore perhaps promotes active learning in a way that physical environments do not. The experience of VR is not just a context around which problems can be analyzed and solved, but its very existence is only possible through the activity of the user—computers must be turned on, the headset must be put on, the video game must be coded, and these activities are done for specific, intended outcomes. Indeed, Olga Gilyazoval writes that if we want to call VR an illusion, we should say that "the illusion is not a condition, but a consequence of the individual's involvement in the events."[10]

But I believe that the ontology of VR taken in itself is neither physical nor an illusion, which are the two sides of a shared dichotomy set up by traditional expectations. It has a unique ontological status. Joohan Kim in "Phenomenology of Digital Being" christens digital being with a new term, reflecting its unique ontology—the *res digitalis* to be distinguished from the Cartesian formulation of the dual being of reality, *res cogitans* and *res extensa*.[11] Kim believes that digital being exists somewhere between the mental and physical realms, and has features that can exhibit characteristics from both realms, but also has features that are independent from either. I would now like to draw upon several scholars attempting to characterize, analyze, and situate the ontology of the digital realm specifically with a focus on those features that apply to the pedagogical practices that are contained in the chapters of this book.

First of all, let me define and set the parameters of what I would include in the category of digital being. Following those who have already written on this topic, I define digital being as anything that can be interacted with that is the result of software which ultimately is generated by the computer which is the hardware. I would include as digital being virtual and augmented environments, which include realistic, fantastic, representational depictions; online discussion boards whose milieu is social; video games; and other digital media.

Unlike physical reality, VR is created, can be deleted, modified, can challenge the notions of place and time, can be duplicated precisely irrespective of time and place, and indeed could arguably live forever.[12] These unique features of VR can be exploited to entertain possibilities and innovations, experimentations, and risks. Not beholden to a physical reality that resists modification and whose modifications are permanent, students may use VR to make predictions about the future, as they did in my course *Weird Science*,[13] or see layers of rock which would otherwise be improbable to reveal on a geologic site as they did in Moysey's and Lazar's Earth Science course. And unlike illusions, VR is not just "in the mind" in a private, solipsistic space, but is publicly accessible, can be created and interacted with collaboratively. These features are analogous to the objectivity that we can attribute to constructed knowledge as constructivism sees it. VR is like constructed knowledge that is formed out of the accretion of interactions, experience, and work, regulated by norms, and which can be analyzed, questioned, and improved upon even though it is not a part of a physically real world. At the same time, it is not like a hallucination that is generated spontaneously without reason or rhyme, and which remains hidden to inspection and is not open to improvement or collaborations, like dreams.

3.3 The "Province of Meaning" and VR

The "world" and our conscious intentions and theses in regards to the *meaning* of that world are bound together in the phenomenological approach. Our perceptions and interactions with external reality depend upon the *noetic* contribution or the intentional meanings that we endow to it and which become a constituent component of that reality. Conditioning PBE experiences are the theses that are brought to the experience. When VR is the tool, it is always a part of the student's intentions that the experience is virtual, no matter how immersive the VR experience may be. For phenomenologists, a core notion at the heart of the approach is the idea that consciousness consists of a self, a ground zero that is the source of the “illumination” of knowledge and meaning. But in the VR experience, everything happens “in front of the eyes,”[14] whether that be a simulated geological site, VR seen through Oculus, or even one’s avatar which is supposed to represent the self.[15] The avatar may represent the self in a relational way, but obviously, even the avatar acts and moves “in front of the eyes” whereas our experiences, perceptions, and thinking happen “behind” them. I am the embodied thinking that looks out into a world; the avatar is the “body” upon which I project and pretend is the “I.”

When we speak of immersion in the experience of VR, I believe that what is meant is how engrossed we can become in the experience, say, in a video game. But even in an intensely immersive state, I do not believe anyone would argue that we forget that VR is not actual reality. Indeed, it would be a frightening prospect if we are immersed in a violent video game to think that we are actually being shot at or holding a real gun. There is a clear ontological demarcation between the real and the virtual that is never crossed in the experience of VR.[16] A notable exception might be the psychological case as discussed by Rosalia and Hillstrom. Psychological dynamics can make it difficult to articulate what reality might even mean. For example, Bessel van der Kolk, a pioneer in Post-traumatic Stress Disorder (PTSD) research, put on the map the idea that when a PTSD victim is triggered, he or she experiences the original conditions of trauma as though it were happening in real time.[17] This alternate reality supersedes the actual reality, at least during the duration of being triggered. Because their chapters lie a bit outside of the phenomenological problematic, I will not be elaborating these chapters further when I discuss the chapters in the book below. My point here is that the experience of VR is typically accompanied by intended meanings that shape how we experience it, and at the heart of the experience of VR is the thesis that it is exactly virtual and not real.

To expand upon what I wrote about in my previous work on Husserl, I would like to bring in those writers on the ontology of VR that draw from Alfred Schütz who further develop Husserl’s ideas. Ollinaho and Shunyang Zhao uses a distinction made by Schütz—“paramount reality” and “a province of meaning”—to discuss distinctions between our everyday reality and VR.[18] I believe that these are crucial notions that help us to understand the parallels and distinctions between real and virtual environments, but also highlights the fact that any reality is framed in the first place by a subject with his or her constellation of meanings, concepts, and experiences. “Paramount reality” is the default reality that we live in and do not usually think about much. It is equivalent to the world of the personalistic attitude in Husserl, a world of our everyday concerns that stretches out like an indefinite horizon, some of which take sharper focus than others at any given time, depending on our concerns. Phenomenologists see this realm as the source of all general and disciplinary knowledge. I have previously written in depth about the relationship between common sense and specialized knowledge.[19] The reason why concrete places and situations are inherently interdisciplinary is because all modes of knowledge stem from the questions and concerns that we originally begin to develop throughout our lives lived in the common sense world. Though academic disciplines are more precise and technical, common sense sets the stage through its questions, and remains a touch point.

I think Ollinaho's rendering of the distinction between paramount reality and a province of meaning is particularly helpful in analyzing VR.[20] We sometimes suspend our engagement in our everyday reality for various reasons, and especially for work—we bracket the physical world through the framework of science to observe and test specific laws and theories; we stipulate an ontology of integers, say, in order to apply mathematical formulas; a child becomes immersed in a game of cops and robbers; we use code to create a virtual world which behaves nothing like the "real" world, and so on. In each case, there is a distinctive cognitive style, understanding of time duration, rules of engagement, and specific experiences of self and sociality.[21] In none of these cases do we forget that there is a "real" world out there—indeed, it is where we always come from and return to.

3.4 VR Projects as "Provinces of Meaning"

I would like now to turn to the chapters contained here to help think through this distinction and to exemplify VR projects as a "province of meaning" in a concrete way. It seems to me an apt way of labeling the way VR is used as a PBE tool in each case. As I said in the introduction, the learning outcomes I will be looking for in terms of what the authors report of the efficacy of VR are abstraction and specialization, which McPhail, for one, cites as indicators for the successful acquisition of field-specific knowledge. He believes that the knowledge we bring in from the familiar lifeworld should only be a starting point for the acquisition of academic knowledge, and not serve as its substitute. The goal of the instructor, he believes, should be to provide opportunities for students to abstract from everyday experiences and gain specialized knowledge with support and feedback from the experts (instructors). Otherwise, students would be done a disservice by not giving them the opportunity to acquire the more focused knowledge of academic disciplines.[22]

Let me begin with "Guidelines for Using Virtual Reality as a Tool for Field-Based Learning in the Earth Sciences" by Moysey and Lazar. The authors believe that field experience, like visiting the Grand Canyon, is indispensable for acquiring the skills and knowledge needed to conduct research in the geosciences. Their interest in VR has to do with addressing the pragmatic limitations presented by traveling to physical field sites—they see in VR an economic and convenient solution to the financial and logistical obstacles that universities often face in supporting student field visits. They go on to analyze which types of technological devices they believe are the most promising, both in terms of their ability to capture the realism of field sites and more pragmatic concerns like cost and availability.

Their attitudes reflect the approach found in traditional PBE—there is an expectation that VR environments should be *like* the physical environment to promote desirable learning outcomes. Indeed, Moysey and Lazar seem to indicate that VR is typically a poor substitute for the real thing.[23] But I would like to make more thematically explicit their tacit acknowledgment that VR has unique contributions in studying these field sites. Many people visit the Grand Canyon every day, but do not necessarily achieve specific learning outcomes that geoscientists would want to acquire. Field sites might be valuable opportunities for learning, but equally important is the knowledge to be gained about those sites and the skills to acquire that knowledge. One of the main learning objectives for students according to Moysey and Lazar is to develop "professional vision," and in order to do this one must be trained to notice patterns and be able to pick out relevant features abstracted from the environment with increasing complexity, guided by the expertise of the instructor. This goal seems to reflect the learning outcomes of abstraction and specialization. In these two outcomes, VR seems to be as or more efficacious than the typical field site trip. The authors write, "[T]hus in some cases a lack of realism may be beneficial, as long as an unrealistic or inaccurate representation of the environment, user actions, or geologic processes would not lead to the formation of misconceptions or other barriers to learning. Likewise, the ability to portray varying degrees of realism in an environment could aid in developing a student's professional vision, e.g., by training a student to identify features and patterns in increasingly complex environments controlled by the instructor."[24] In other words, it is helpful to distill relevant features from the environment to focus in on those features that geoscientists are interested in.

Later, in discussing the narrative and interactive functions of VR, they write that it supports differentiated and scaffolded learning effectively.[25] VR does not compare to the realism of a physical environment, but in narrowing down the field of vision to the "province of meaning" that is relevant for geoscience, it appears that VR can concentrate and amplify features of the environment that are important for the acquisition of expertise in the field. VR is a kind of reality that can be modified—extraneous features may be deleted, and relevant features highlighted. For example, 3D modeling terrain software is used quite common in the geosciences, and what it helps us to visualize would not be possible using the naked eye in a real environment.

MacDonald, in "Visualization and Analysis of Environmental Data," discusses the efficacy of mapping for learning and utilizing economic and environmental data. Maps in general have always been "virtual" in a sense. They provide an overview of significations and information as much as they visually stand in for physical places. It is therefore not a stretch to correlate the symbolic nature of the traditional map to the virtual one. Tung Fung et al. write in regards to virtual maps that "virtual environments may be considered as a new and developing geographic language that is 3-D, immersive and reality-transcending, arising out of languages… manifesting the meaning of the world."[26] Maps, even those on paper, are already a depiction of abstract meanings. In the case of MacDonald's class, students spend a good deal of time familiarizing themselves with maps of the city despite the fact that many of them have lived here all of their lives. Obviously, being immersed in a place does not necessarily give one the necessary perspective to analyze its data. Maps provide an abstract, informed perspective in which the outlines of the city are depicted alongside significant information—students are able to see relationships and correlations that economists observe and make inferences from. MacDonald writes, "In this way, virtual place can both *enhance* the study of physical space and overcome the limitations of access by enabling study in urban environments where physical observation of particular places is limited."[27] VR helps us overcome the limited perspective that we typically occupy in the lifeworld at any given moment—being embedded in a local environment, as far as our eyes can see. Students' lived experiences of the city might be a familiar base to start from, but economic analysis must abstract and differentiate from that.

Ting and Swift use mapping as well, but their approach differs from the previous two chapters in that they focus on data, not of the place itself, but of the community that surrounds the place of focus (i.e. the theater, which they actually do visit in person). Their objective is to demonstrate the role of the audience (the community) in the design of the theater. It would take us too far afield to reconstruct Husserl's ideas about the intersubjective nature of the perception of reality—that all along it had never been just the lone individual's confrontation with a singular object, but that perception was conditioned by the intersubjective "we" that shapes our experiences in full. He believes that subjects alongside other subjects together construct three-dimensional space and time for us to perceive the world as we do. Furthermore, it is our collective planning and work that actually build the places that populate our towns and cities. The "we" literally creates the world.[28] But the community's influence is invisible; it does not appear in the fabric of the physical places that we see and encounter. With VR, Ting and Swift make explicit the characteristics of the community that help to form and shape the development of a particular theater.

In Lansiquot et al.'s "Computational Thinking and the Role-Playing Classroom," the learning objectives are to support students in developing computational thinking and thesis-driven writing, as well as supporting general cognitive skills, like critical thinking, collaborative learning, creative expression, and communication skills. These are not discipline-specific, and it may be argued that they are more self-regulating and in less need of expert feedback for its successful acquisition, though social mediation by peers and instructors are always a part of the constructive process of learning.[29] Schunk writes, "[E]quilibration is an internal process (Duncan, 1995). As such, cognitive development can occur only when disequilibrium or cognitive conflict exists. Thus, an event must occur that produces a disturbance in the child's cognitive structures so that the child's beliefs do not match the observed reality. Equilibration seeks to resolve the conflict through assimilation and accommodation."[30] In other words, students have an inherent tendency to assimilate new knowledge in the first place, and in the second place, they do so according to old frameworks. One is awakened to new information by having the old frameworks challenged, which in turn sets the conditions for further assimilation, which in the end expands the original framework. Schunk believes that the classroom that encourages such a process uses big ideas, and allows students to do research-based, problem-solving projects in a collaborative setting.[31]

The authors of "Computational Thinking" design a curriculum exactly in this way—they assign students a coding project on Alice (a game-designing software) that aims to create a game world through collaborative effort. The authors are conscious of the correlation between the project and the way constructivists describe the learning process in general. They write, "Constructivism posits that learning is an active process where learners create new knowledge from their previous knowledge based on their perception of reality."[32] Though at times students struggle, the authors conclude that having a concrete end-goal is both motivating and supports the process of learning. The "province of meaning" here (the fantasy stories that are the basis for the coding and writing projects) results from the creative imagination of the students, and cannot exist without the collaboration and work of all those involved. In this way, the starting-points of the projects are also "virtual." But once the VR is created, it can be seen, navigated through by avatars, interacted with, and so on. Their collective work culminates in an objective environment for all of the participants and is not merely a private hallucination that is hidden. Ollinaho points out that though VR parallels physical reality, "[v]irtual worlds, however, offer different types of resistance which require different effort to overcome, they place different tasks, permit me to carry on through different plans than the 'real' world does."[33] VR's resistances and tasks are different from those of the lifeworld, but no less efficacious for learning. In this case, the fictional fantasy stories that engaged and motivated students helped set the conditions for demonstrably improved outcomes in coding and writing in the Problem-Solving with Computer Programming course, according to the authors.

3.5 CONCLUSION

In *School and Society*, John Dewey was an early promoter of PBE. He saw the traditional classroom as too formal and restrictive to support the concrete, experiential-based, active, and collaborative learning that he believed was possible and ideal.[34] Rather than sitting inside an isolated room away from the real world to memorize rote facts and numbers, he believed that a part of education should be to cultivate civic and ethic consciousness and to help students be aware of and know how to solve real-life problems. Since Dewey, much has been written about the value of PBE and what approaches work best. At least some educators understand that PBE is a high-impact educational practice, and many have adopted PBE as part of their curriculum. But because the use of VR in the classroom is a more recent phenomena, not as much has been researched and written about in terms of its efficacy for learning. Indeed, if VR is used or discussed, it is frequently held up to the expectations we have of real, physical reality and often falls short. My goal was to bring out and discuss the unique features of VR for promoting learning objectives. VR tools and projects provide a concrete, experiential-based context in the way a physical place might. But VR also has unique features that liberate it from the limitations of actual reality. Actual reality is hard to edit, cannot be easily deleted, and has trouble depicting future possibilities, experimental ideas, and masquerading as fiction for periods of time. In VR, however all of those things can be entertained in a way that the chapters contained here demonstrates have been efficacious for learning overall.

Acknowledgments I would like to thank Salem Art Works in Salem, NY, for their writing residency in summer 2018 during which I reflected, researched, and planned this chapter. Being surrounded by craft and maker artists was a good reminder of what VR was *not*, which was a much-needed counter perspective. I would also like to thank Louis J. Colombo and Róbert Jack, both of whom have helped me think through problems and improve my writing in this particular piece as well as in others over the years. This is a long overdue thanks.

Notes

1. Ossi Ollinaho, “Virtualization of the Lifeworld,” *Human Studies* 41 (2018):193–209. See the section “Province of Meaning” below.
2. There are critics of constructivism that are concerned for maintaining “objective” standards of disciplinary learning that these two metrics capture, such as Graham McPhail in “The Fault Lines of Recontextualisation: The Limits of Constructivism in Education,” *British Educational Research Journal* 42, no. 2 (April 2016): 294–313; PennyVan Bergen and Mitch Parsell, “Comparing Radical, Social and Psychological Constructivism in Australian Higher Education: A Psycho-philosophical Perspective,” *The Australian Educational Researcher* 46 (2019): 41–58.
3. Laureen Park, “Varieties of Place: A Phenomenological Analysis of Place-based Education,” in *Interdisciplinary Place-Based Learning in Urban Education: Exploring Virtual Worlds*, ed. Reneta Lansiquot and Sean MacDonald (New York: Palgrave Macmillan, 2018).
4. Donald Hoffman, “Perception Deception,” *Scientific American* 313, no. 5 75 (November 2015). Additionally, he has a forthcoming book on the topic that expands the argument.

5. For example, Christine Constantinople at NYU, Beau Lotto at University of London and Anil Smith at University of Sussex.
6. Thomas Kuhn, *The Structure of Scientific Revolutions* 3rd ed. (Chicago: The University of Chicago Press, 1996).
7. See *Ideas Pertaining to a Pure Phenomenology and to a Phenomenological Philosophy (Ideas II)*, trans. Richard Rojcewicz and André Schuwer (Dordrecht: Kluwer, 1993), 20.
8. Husserl writes that philosophy is a "rigorous science." See Husserl, Edmund, *Logical Investigations*, trans. J.N. Findlay (NY: Humanities Press: 1970), 42. His is a *science* and not merely a "psychological" account.
9. Ollinaho, "Virtualization of the Lifeworld."
10. Olga Gilyazova, "The Relationship Between Virtual and Actual Reality: Phenomenological/Ontological Approach." *Journal of History Culture and Art Research*, 8, no. 1 (2019): 200.
11. Joohan Kim, "Phenomenology of Digital Being," *Human Studies* 24, no.1/2 (2001): 87.
12. In characterizing VR here, I draw from Kim, "Phenomenology of Digital Being" and Gilyazova, "The Relationship Between Virtual and Actual Reality."
13. Due to the lack of space, I will not be elaborating upon my own experiences with VR in the classroom, but I teach an interdisciplinary class with ten guest lecturers from different disciplines. The culminating project is a VR depiction of the future of humanity, including a virtual world which groups of students collaborate on, populated by avatars which each student designs individually. Students often create dystopias that serve as warnings against certain cultural trends. On occasion, students depict utopias that reflect a cleaner, more egalitarian future. Of course, none of these exist in the here and now, but reflecting on such possibilities helps students to clarify and crystallize their ideas what it means to be human.
14. Ollinaho, "Virtualization of the Lifeworld," 199.
15. Ollinaho, "Virtualization of the Lifeworld," 199.
16. I concur with Gilyazova when she writes, "Although the functional openness unlocks the ontological boundaries between the user and VR (to the extent of a deceptive feeling of absolute presence in the cyberspace), it is not able to eliminate the ontological nature of the boundaries" (Gilyazova, "Relationship Between Virtual and Actual Reality," 200).
17. Bessel van der Kolk, *The Body Keeps the Score* (New York: Penguin Books, 2014).
18. I have already referred to Giliazova's and Olihano's works, but I will also be referring to Shunyang Zhao's "Consociated Contemporaries as an Emergent Realm of the Lifeworld: Extending Schütz's Phenomenological Analysis to Cyberspace," *Human Studies* 27 (2004): 91–105.

19. Laureen Park, “A Study of Integration: The Role of *Sensus Communis* in Integrating Disciplinary Knowledge,” in *Interdisciplinary Pedagogy for STEM: A Collaborative Case Study*, ed. Reneta Lansiquot (New York: Palgrave Macmillan, 2016).
20. Ollinaho, “Virtualization of the Lifeworld.”
21. Ollinaho, “Virtualization of the Lifeworld,” 198.
22. McPhail, “The Fault Lines of Recontextualisation,” 304.
23. According to Stephen Moysey and Kelly Lazar, “[f]or example, the feeling of the sun on one’s skin while walking down a trail in the Grand Canyon (regardless of whether pleasant or blistering) contributes to affect in a way that would be impossible to achieve within current commercial VR technologies.” See Chap. 7, “Using Virtual Reality as a Tool for Field-Based Learning in the Earth Sciences.”
24. Moysey and Lazar, “Using Virtual Reality as a Tool for Field-Based Learning in the Earth Sciences,” 106.
25. Moysey and Lazar, “Using Virtual Reality as a Tool for Field-Based Learning in the Earth Sciences,” 106.
26. Tung Fung, Yee Ling, Hui Lin, “From Paper Maps to Virtual Reality; a View from Hong Kong,” *The Cartographic Journal* 41, no. 3 (December 2004): 263.
27. MacDonald, 71.
28. Husserl, *Ideas II*, 205.
29. Lev Vygotsky, a Russian Psychologist, put the idea of “social” constructivism on the map, but this idea is probably a part of all constructivist theories of knowledge to some extent.
30. Schunk, *Learning Theories*, 238.
31. Schunk, *Learning Theories*, 261–282.
32. Lansiquot, Cunningham, and Cabo, “Computational Thinking and the Role-Playing Classroom,” 153.
33. Ollinaho, “Virtualization of the Lifeworld,” 200.
34. John Dewey, *The School and Society* (Mineola: Dover Books, 2001), 22.

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CHAPTER 4

Information Literacy in Place-Based Interdisciplinary Teaching and Learning

Anne E. Leonard

Abstract This chapter explores the role of information literacy in virtual or hybrid place-based interdisciplinary courses. Whether teaching as a guest lecturer or as a co-instructor, I infuse information literacy competencies into assignments, relying on the *Framework for Information Literacy for Higher Education*. Four of the six frames of the Framework map especially well to interdisciplinary teaching and learning: *information has value*, *authority is contested and contextual*, *research as inquiry*, and *searching as strategic exploration*. Through searching in special collections and archives and integrating digitized primary sources into research projects students engage in a virtual exploration of place, becoming familiar with it through digitized primary sources. At the same time, the interdisciplinary approach helps students gain a critical perspective on information production and preservation.

Keywords Information literacy • Interdisciplinary learning • Interdisciplinary teaching • New York City • Place-based learning

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In this chapter, I explore information literacy in virtual or hybrid place-based interdisciplinary undergraduate courses. Through searching of digitized archives and special collections, students engage in a virtual exploration of place, becoming familiar with it through its cultural objects that are preserved and distributed digitally. Virtual learning is by definition place-based, even though the physical experience of the place is outside of real time and physicality. Virtual experiences of a physical place enhance students' understanding, as they permit repeat visits to a place, or experiences of a place when an entire class visit is not possible or feasible. This permits students to develop a shared knowledge base more quickly and easily, which facilitates entry into the course content.

Whether teaching as a guest lecturer or as a co-instructor, I infuse information literacy competencies into assignments and classroom activities. I rely on the *Framework for Information Literacy for Higher Education*,[1] hereafter called the Framework, to shape the specific competencies that I teach. Four of the six frames of the Framework map especially well to interdisciplinary teaching and learning: *information has value*, *authority is constructed and contextual*, *research as inquiry*, and *searching as strategic exploration*. I discuss each of these with respect to three interdisciplinary courses I have either guest lectured or co-taught. In the courses for which I have guest lectured, I offer a case study of learning through virtual primary sources in information literacy sessions. Co-teaching a semester-long course offers more opportunities to go deeper with the information literacy frames and designing assignments that help students meet one or more of the dispositions that demonstrate achievement of multiple frames. I explore how information literacy is essential to place-based learning and to interdisciplinary learning.

Whether teaching toward information literacy in my role as a guest lecturer or as a classroom instructor, I rely on a few essential instructional design principles, including active learning and a constructivist approach that acknowledges students' lived experiences, prior knowledge, and experience. I believe in recognizing the learner beyond the college experience—lifelong learning—and approach learning as situated, or place-aware, drawing upon civic resources such as public libraries and free, open scholarly resources such as subject repositories.

Most undergraduates learn about libraries and their resources through what is commonly referred to as the one-shot, meaning a one-off workshop during which a librarian demonstrates library search tools and introduces search strategies intended to help students locate information for an assignment. Recent criticism of the one-shot questions its relevance to information literacy. Teaching to impart information literacy is not solely the domain of librarians. As a librarian who inhabits multiple roles: that of classroom instructor, one-shot leader, and workshop facilitator, I see from multiple viewpoints how the one-shot can familiarize students with research concepts and prepare them for the information literacy journey, not least by easing their library anxiety. Yet it if the one-shot is not timed to coincide with students' research needs, or if the classroom instructor has not explained in advance the value of library sources for the research assignment, it can be a mystifying and abstract waste of time for all, though perhaps the visit to the physical library has value. Assignments grounded in an understanding of place depend on students' ability to make sense of a range of primary sources.

4.1 Literature Review

The answers to the most stimulating questions about place-based learning and information literacy cross disciplines and praxes. The work of several archivists, librarians, and scholar-educators exploring ways to implement and improve virtual place-based learning and teaching, and using archives and special collections in teaching is a pleasure to explore, and a challenge to integrate. While the Framework does not delineate archival objects (whether physical, digitized, or born digital), other efforts to define primary source literacy and establish learning objectives speak to the acquisition of knowledge as well as the development of skills in a researcher who is gaining information literacy from archival sources. In an attempt to define information literacy outcomes for special collections, Carini explores what and how an information literate person should know and also offers a set of concepts for teaching with primary sources that include beginning, intermediate, and advanced abilities moving from simple to complex, or concrete to abstract. This suggests that acquiring primary source literacy is a process.[2] Similarly, the information literacy frames *searching as strategic exploration and research as inquiry* both indicate an iterative potentially non-linear process by which a learner acquires information literacy competency. Carini emphasizes a learner's acquiring of knowledge of historical context and historical thinking habits of mind while also acknowledging that archival and special collection research takes place across disciplines, not solely in the domain of history.[3] Because primary sources share few characteristics with textbooks, course packs, or other information sources that undergraduates are typically expected to learn from, The Society of

American Archivists and the Rare Book and Manuscript Section of the Association of College and Research Libraries propose *Guidelines for Primary Source Literacy*.[4] These *Guidelines* articulate a scale of competencies, each of which builds on the previous, helping an instructor or librarian situate the scope and context of the lesson based on the learning objectives. The *Guidelines* also introduce interrelated concepts—analytical, ethical, and theoretical—that the users of archives should grasp in order to make the best use of primary sources in their research; familiarity and practice yields increasing mastery of the concepts. Tritt and Carey document teaching with digitized archives in the undergraduate classroom, as do Schmiesing and Hollis, who also rightly recognize the significance of the form that information takes.[5] Proof of integration of information, whether it be primary or secondary sources, or original research and empirical observations, is the ongoing role of the classroom instructor and the librarian. Wagner and Smith's research on undergraduates' perceptions of archives and their users shows us that while students may be aware of archives, they have not usually used them, thinking of archives as loci for the more serious or advanced research efforts of faculty and graduate students.[6]

4.2 The Value of Archives and Special Collections

Even when the primary sources within the special collection or archive have been digitized, they still hold the place they originated, the place they are of, within them. Archives and special collections are inherently place-based. Archival objects, representing a wide range of media and typically unified by a theme (as in a local or regional history collection, which underscores the importance of place), are preserved and accessible together. Yet the creator of a nineteenth-century trade card advertising a local florist would never have conceived of that item sharing space, and contributing to meaning-making, alongside a 1960s-era flyer promoting a political protest. In the special collection that documents the history of a place, such as a historical society or local history/genealogy collection, both are presented as artifacts documenting the history of a place at different points in time.

Learning from primary sources is inherently an interdisciplinary experience, as these sources embody a range of cultural, historical, and social artifacts of human experiences without a filter or an interpretation. Virtual research environments enhance student engagement with the research process and yield integration of higher-quality research resources into student work (more historical primary sources such as photographs, maps, and datasets, fewer weak web-based content curation sites such as BuzzFeed or Bustle). Virtual research environments allow access to an enormous corpus of primary sources, all accessible through a web browser. This is fundamentally different from physical environments, where catalogs, finding aids, and descriptive materials that organize and index physical primary sources exist in a range of physical locations. The physical locations of archives and special collections themselves present multiple access issues. Some collections require institutional admission fees, as for a museum; all post rules about interacting with the objects and some even enforce unspoken codes of conduct. All have limited hours of operation and limits to what one person can experience in a single visit. Punzalan and Caswell propose important directions for archives to foreground social justice in their policies and collections, becoming more inclusive and thereby more just.[7] One physical, analog archival object cannot occupy multiple locations simultaneously, yet the virtual version of the same object certainly can appear in infinite browser tabs simultaneously. This is useful for classroom explorations and interrogations and allows for learners to return to the object for further study, either independently or in the classroom setting. Initial explorations in archives and special collections may take on attributes of a fishing expedition, yet the overall experience highlights students' authentic reactions to and interpretations of archival objects.

4.3 Introduction to Language and Technology: Situating Information Literacy

As a guest lecturer in the interdisciplinary course Introduction to Language and Technology, I prepare and teach a workshop—more of an active learning experience than a passive lecture—in advanced library research methods. Students learn not only how to use filters in the library's discovery layer and databases productively, but also why to use them; in effect, why information in various formats acquires the status it has. Students can immediately apply the lesson to the research components of two assignments, the annotated bibliography and the research paper. In the library lesson, we do not virtually move off-campus to explore digitized primary sources; instead, students learn about research as an iterative process, in which continuous refining of the search strategy yields ever-more-relevant search results. The workshop begins with an interactive exploration into the characteristics of reliable information sources and concludes with some practical strategies for reading peer-reviewed journal articles. Using Poll Everywhere to gather and display students' responses to a prompt asking for their thoughts and opinions about the characteristics of reliable information sources, we then apply these criteria to live searches in the library's collection. One student's response to the prompt about the characteristics of a reliable information source, "footnotes," indicates an awareness of scholarly communication styles and the importance of documentation of sources, both of which are knowledge practices of someone achieving information literacy.[8] The information literacy frames *information has value* and *research as inquiry* guide the interactive evaluation activity. Students' research into the quality of online information leads them to develop a habit of mind to query, even interrogate, the authenticity and comprehensiveness of any information source. To develop fluency with r*esearch as inquiry*, we use OneSearch, a discovery layer search interface that retrieves results from the library's print resources (print and eBooks) and databases (articles) simultaneously. A typical list of results retrieved is not the end of the process or the goal of the lesson; rather, it is the starting point for the application of the frame *research as inquiry.* I guide students through the use of filters and facets to narrow down a potentially overwhelming set of results in a range of media. As students apply filters and facets to their results, and even experience search as an iterative process if they start over or refine their search keywords and strategies, they are developing knowledge practices pertinent to the frame *research as inquiry.*[9] We discuss the importance of the date of publication, the format, the audience, the domain of knowledge, and other aspects of articles, books, and other media retrieved. In addition, the frame *information has value* becomes clear almost as soon as students begin refining results using the facets of the search interface; not every library provides access to every piece of information, and the reasons for this are almost always economic.

In teaching students about reading scholarly articles, I encourage them to seek out the author's peer community of scholars through a citation database to determine how, how frequently, and how recently the author's peers have cited the work in question. Who has cited the work in question, and what influence do they have? Can we find proof of author's authority on the topic by investigating how their other works have been cited? This evidence of scholarly communication allows students to see themselves as beginner participants in scholarly communication. As a result, generating a Works Cited or References list, rather than an onerous task to rush through after writing the paper, is a means to participate in scholarly communication. By citing, they are assigning value to the articles and other sources they have selected. In this workshop, I use examples from my own experience as a researcher and scholar to illustrate scholarly communication strategies and show how scholarly communication—acknowledgment and citation—exemplifies *information has value*. Autobiographical approaches to modeling research behavior are effective. I encourage other guest lecturers to tell their own research stories that illustrate the moment that a solution to a research problem became clear to them, or when they became aware that they had leveled up with their own process of research and were able to conduct research more effectively, articulate more relevant research questions, or even write or communicate better. To model academic research behavior for students can powerfully orient them to the scholarly communication norms of their chosen disciplines and majors.

4.4 Black New York: Interdisciplinary Interrogations and Sharing Virtual Space

Black New York is an upper-level interdisciplinary course in which students trace the Africana experience in New York City through primary source research, visits to cultural institutions throughout the city, guest lectures from a range of disciplinary perspectives, and cross-disciplinary readings and discussions. When I was invited to guest lecture in Black New York, I facilitated a virtual class visit to digitized special collections and archives. Although students did not get the off-campus experience of visiting a cultural institution in real time and space, the library session made the most of a 60- to 90-minute class meeting. In the classroom, students worked in small groups to work with digitized archival objects that I selected based on course readings. Students interrogated archival photographs, musical scores, manuscripts, and newspaper articles to learn about the information they contain, and to consider why and how these particular archival items were preserved and distributed. Working in groups, they studied an assigned digitized archival object and responded to several prompts:

- Can you describe the speaker, writer, photographer, or narrator's point of view?
- Who is the intended audience of this piece?
- How has your view of the Black experience in New York City been shaped by encountering this primary source?
- Identify a question, contradiction, or cultural or political tension suggested or embodied in this work. How does it contribute to or complicate a particular viewpoint or perspective on the Black experience of and in New York City?

Each group reported back to the class and the discussion exemplified the knowledge practices of information literacy frame a*uthority is constructed and contextual.*[10] With this in mind, students later became authors and information curators as they created an online map of cultural institutions in New York to display their research projects.

As a first-time guest lecturer in Black New York, I designed and taught a 90-minute class to lead students on a critical tour of digitized archival objects and primary sources that connect to the New York City places and people they study. My initial guest lecture in this course is the first time I applied the concept of virtuality to teaching and learning about archival primary sources. To prepare for the activity, I searched digitized archives and special collections such as the Digital Public Library of America (dp.la) and the digital collections of the New York Public Library to identify primary sources that were referenced in course readings, highlighted the Black experience in areas of New York students studied, or aligned with recent or upcoming class field research visits. I emphasized the free access to these and similar collections; the user need not authenticate nor pay to retrieve virtual primary sources through these and similar research portals; they exist for the public good. The digitized objects I selected were only revealed at the time of the workshop; with more time or an additional workshop, I would task students with the search for relevant archival objects. One group of students interrogated a digitized photograph depicting a Black multigenerational group at home, created in the 1930s as part of the Federal Art Project. The students were disappointed to learn that the photographer was not black as well; the identity of the author or creator was just as important as the subject to them. In this case, students showed me I still had plenty to learn about the frame *authority is constructed and contextual.*

The second time I was invited to guest lecture in Black New York, I inhabited the identity of embedded librarian,[11] meeting with the class several times. I built upon my original 90-minute introduction to digitized archival objects and primary sources, helping students with the next phase of their research: documenting and geolocating their place-based research projects onto shared digital maps through a commercial mapping platform familiar to many, Google Maps. This particular virtual geographic tool is not intended for educational use or for group projects, so delivery of a complex multi-authored project encountered a few impediments. At the time I led students in this project, free (or freemium) digitized mapping tools that we could realistically master were rather underdeveloped, and we lacked technical assistance or support. With more time and support, I would choose StoryMap, MyHistro, Omeka, or another platform that enables students to group curate their work, tell their stories visually with digital media, document their sources thoroughly and ethically, and make their work available to the public. Throughout the project, I supported student research through the creation of a research guide[12] where students could resume the research task in the virtual special collections and archives we explored, apply the search strategies and tools we used to other virtual archives and special collections, and connect to library subscription databases and electronic resources.

Interdisciplinary teaching and learning affords opportunities to bring a critical perspective on information production and to put students in the role of information producer, curator, and evaluator. Wide interest in digital humanities has helped cultural institutions with digitized, virtual collections integrate their collections into undergraduate teaching. We all benefit from growing recognition that virtual primary sources engage students in learning about place, history, and culture. The primary sources research activity meets two types of course learning outcomes: content learning outcomes and general education learning outcomes. Among several course content learning outcomes, the following directly speak to information literacy competencies:

- Use different sources from history, literature, the arts, politics, and sociology to understand the experiences of Africana people in New York City.
- Use archival and field research to trace the movement and activities of Africana people New York City and through its neighborhoods.

Course content learning outcomes specifically address reckoning with different kinds of primary sources, in a range of research settings including archives and special collections. The general education learning outcomes refer to developing the habits of mind needed to analyze course material from research visits both virtual and physical. General Education learning outcomes and means of assessment include skills development by "acquir[ing] and us[ing] the tools needed for communication, inquiry, analysis, and productive work," assessed in part by curating and analyzing research materials. Integration of knowledge from across disciplines is assessed by evaluating primary and secondary sources from across disciplines, as well as analyzing materials from cultural and research institutions, both physical and virtual.[13] Both categories of learning outcomes represent the acquisition of information literacy dispositions, as a student who is learning to think critically about sources gathered from field research and archival research progresses toward the information literacy disposition of "recognizing that authority may be conferred or manifested in unexpected ways."[14] In addition to supporting students' independent investigations into the virtual research environments I introduced, the research guide housed collaborative map-making efforts, the visualized evidence of their place-based research.

4.5 Learning Places: Physical and Virtual Interdisciplinary Environments

I co-teach a semester-long interdisciplinary course, Learning Places: Understanding the City, in collaboration with a colleague from another department, most often the Department of Architectural Technology. In the course, we use a case study approach to learn about a particular New York City place from multiple disciplinary lenses. Students learn about the place selected for study through repeated visits to the site to observe, sketch, photograph it, written assignments that document the experience of visiting the site, and through visits to special collections and archives to learn about historical primary sources. To meet learning outcomes adjacent to information literacy, I facilitate several research visits to local special collections and archives held in museums and public libraries where students can browse, search for, and discover a range of historical primary sources and integrate them into their pursuit of an answer to the research questions they posit. These visits lead to a site report that informs the development of a research question or topic that they explore throughout the semester. Through the archives visit, students learn about the process of information creation and gain comfort with the sometimes-non-linear journey of searching and browsing to discover and research. Searching for archival objects that tell the story of the location chosen for the case study demands that students develop research strategies, which emerge as they pursue background research, study secondary sources, and undertake site visits to gain familiarity with the place. In addition to learning about a place virtually, through archival objects, the students explore the frame *searching as strategic exploration* quite literally as they embark on in-person explorations of the site chosen for study as well as virtual explorations facilitated through historic and contemporary digitized maps. It is in Learning Places that the interrogation of digitized archival objects really converges. In Learning Places, the students encounter primary sources in their analog, curated habitat—the special collection and archive—and then later visit their digitized, virtual versions as often as needed. We make use of the rich, unparalleled collections of our city's public libraries, yet there is still an essence of the high temple of learning, and all its exclusivity, in the process of visiting, observing, recording observations, and writing conclusions/reflections. The simple search tools that facilitate access to virtual objects shed exclusivity; students quickly gain comfort with searching. These virtual visits to the primary sources introduce students to metadata, as they need to develop a vocabulary to build keywords. Since students are required to document and cite all information they use in their research projects, they learn to interpret metadata. No longer is an image, newspaper article, video, a low-hanging virtual fruit to right-click, download, and paste into one's work. The origin, preservation, creator, and subject must be considered and acknowledged. This leads students to consider critical questions about special collections. Who is represented by, and in, the collections? Who are the collections for? Why are these archival objects and primary sources preserved? By what process are some objects selected for digital preservation and released into the virtual world? The information literacy frame *authority is constructed and contextual* guides this interrogation, as students begin to consider not only what is included in a special collection as well as the cultural, political, and social forces that bear on institutions' decisions about preserving and digitizing the past. Using simple search strategies—for example, searching with the name of a street or a neighborhood to locate primary sources about a specific place—students uncover complex, even difficult, primary sources. An example of a particularly complex primary source is a digitized historical fire insurance map. The collections we made use of are especially rich in these types of maps, so students' research inquiries over time and space facilitate repeated engagement with these virtual representations of place. Developed in the nineteenth century to help insurance companies determine the risk of insuring buildings against fire loss in American cities, they reveal details about the built environment at a specific moment in time, including building composition, purpose, and ownership, as well as transportation and utilities infrastructure. Since the fire insurance companies regularly updated these maps, they enable temporal comparisons and help those who view them understand change over a specific period of time. Our class research visits to special collections allowed students to view and study physical maps before learning how to find their virtual counterparts. Maps are abstractions of physical places, yet the experience of using physical and then virtual maps to compare historical and contemporary conditions makes the places studied seem more real, mutable, and changing over time.

Students encounter information via various means during their virtual visits to special collections and archives: searching using keywords, browsing by scrolling through a thematically arranged collection, or using a combination of both to retrieve relevant primary sources and serendipitously discover much more. Whatever the means to locating a particular relevant primary source, the virtual browsing or searching tends to flatten out the experience, although it is usually a more efficient means to find information. A real-time visit in physical space affords the opportunity to observe other users engaged in the same activities or using the physical space for other purposes. Undoubtedly, the virtual visit saves time and effort of the researcher, both precious resources in undergraduate teaching and learning. Yet a strong and active concept of place is still essential in this virtual exploration of historical primary sources. In the case of one student's search for a photograph illustrating transportation modes from the past, the location where the photograph was made became essential. Any photograph depicting a horse-drawn cart was insufficient; the metadata of the image had to specify a location relevant to her research, and the student searched until this metadata requirement was satisfied. Successful citation and documentation of digitized primary sources requires developing a careful habit of mind: considering what is important to one's scholarly community, what to do when there is no personal author, or when the metadata do not provide enough information to fulfill the norms of citation. Given that the holding institution or library did not create the primary source, or that the creating institution may no longer exist, who then is the creator, the author?

This intersects with the information literacy frame *authority is constructed and contextual*. Students become authorities when they locate and select digitized archival objects that help them respond to a research question or problem. Students also become authorities as they generate, write, document, and curate primary sources in the form of field observations and data collection, an important interdisciplinary aspect of work in this course. Since their works are archived on the institutional learning platform, the possibility exists that they are the authors of primary sources of the future, just as the letter writers, cartographers, photographers, newspaper reporters, graphic designers, and others whose work is captured and digitized in the archives and special collections that we use.

4.6 Conclusions and Directions for Further Research

The frames from the Framework for Information Literacy that I have explored with students are just a few inroads or thresholds toward information literacy that amplify the learning affordances of virtual environments. Virtual primary sources have much to offer those in the process of becoming information literate (an ongoing process for all of us). Encouraging students to consider which voices and experiences have been excluded, to imagine what primary sources could have been preserved and digitized, and how that would allow a writing of human experience from a wide, inclusive, multi-voiced perspective induces interdisciplinary learning as students integrate a range of perspectives. Special collections and archives also benefit from integration into undergraduate teaching and learning. Digitized, network-distributed, and virtual primary sources can be infinitely studied, interpreted, and interrogated, even as the analog object may be physically preserved away from physical contact, or less accessible because of institutional protocol in place intended to protect it from damage.

Future praxis puts students more firmly in the role of authors. They may more actively participate as documentarians, even as oral history subjects, as enlightened and progressive institutions seek to fill in gaps and silences and interact with a broad base of their constituents to preserve inclusively. Interdisciplinary learning experiences foster the future of interdisciplinary thinking.

In Black New York, students explore *authority is constructed and contextual* when they interrogate digitized archival objects, questioning the artistic and institutional decisions that led to that object's preservation. In a digital mapping exercise, students engage with the frame *searching as strategic exploration* as they first select and research a place and add it to a collaborative digital map, then encourage viewers of the map to explore a place in New York, virtually, through the research annotations they embed into the map. The frames *information has value* and *research as inquiry* guide the evaluation game, as students' research into the quality of online information leads them to a habit of mind of querying the authenticity and comprehensiveness of any information source. Finally, *searching as strategic exploration* informs the process of virtual archival research in Learning Places, as students search with their questions in mind, but without advance knowledge of the existence of a single archival object that will answer these questions. They synthesize the evidence they find that is distributed among multiple objects to create new knowledge of the place-based problems they investigate.

Virtual archives and special collections enrich the experience of learning from primary sources. Quotidian objects have value as introductions to the study of a place and the forces of how that place changed over time. As institutions and their archives and special collections redevelop their practices that foster inclusion and diversity, the users, both physical and virtual, see themselves reflected in the collections, which in turn stimulates more use by a more diverse user group. Many special collections consider public accessibility to be a preservation strategy, rather than a liability that may lead to theft, loss, or damage; this is yet another reason to support and engage with virtual archival objects and primary sources. Many groups and individuals may not presently see their experiences reflected in the visual and text-based primary sources preserved within special collections and archives. As institutions come to terms with their exclusionary past practices and move forward to build diverse and inclusive collections, these collections of primary sources will reflect the physical world and its inhabitants. Our shared cultural heritage will be far richer as a result.

NOTES

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CHAPTER 5

Visualization and Analysis of Environmental Data

Sean P. MacDonald

Abstract The virtual exploration of place has been employed in a variety of learning environments across many disciplines, creatively expanding upon the experience of place. This chapter explores the value of mapping environmental data as a tool that can enhance students' virtual exploration of place as they investigate local environmental policies and problems within their own urban surroundings. This visualization project engages students in making meaningful connections between the theoretical study of local and global environmental problems and the "observation" and investigation of these data using mapped data. The virtual learning environment is viewed as one that is interactive, exploring how the resources of urban settings can be cultivated in designing virtual methodologies, and where the experience of place can be realized as geographic place.

Keywords Environment • Mapping • Virtual place-based study • Visualization

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This chapter examines the introduction of a mapping project in an interdisciplinary Environmental Economics course as a tool to facilitate students' virtual exploration of place with a focus on local environmental policies and problems. The goal is to encourage students to develop a familiarity with the environmental landscape of the urban environment of New York City, a setting they already have some familiarity with. At the same time, this visualization and analysis project seeks to engage students in making meaningful connections between the theoretical study of local, and global, environmental problems and the observation and investigation of these data using mapped data.

The theme of the Environmental Economics course focuses on an exploration of how economic policy and sustainable growth can be informed by innovative technology, planning, and design, while incorporating the goals of social, economic, and environmental justice. It explores how economic priorities can be effectively applied to the goal of addressing the challenges of global climate change and how progress toward that goal can and has involved initiatives from the community to the international levels.

At the same time, the course theme encompasses the valuable contributions and insights of other disciplines through the perspectives of invited guest lecturers from fields outside of economics, as well as by interdisciplinary readings and activities that are central to informing the course's theme. The goal is to expose students to the viewpoints, knowledge, and methods of inquiry of other disciplines, while enabling them to visualize the connections between the focus of environmental economics and some of the issues and themes of related disciplines. This interdisciplinary focus also seeks to encourage students to envision how they might incorporate the perspectives of other disciplines into their own course research projects.

The students in the course also bring with them the varied perspectives shaped by their own major fields of study, including computer science, nursing, hospitality management, and engineering. This diversity of disciplinary perspectives comprises an integral component in the process of making connections to the views and contributions of other disciplines to a broader, more comprehensive study of topics in environmental economics. It has also been effective as an inspiration to students in the design of their own semester research projects.

Place-based learning and research projects have been a central feature of the class, where the emphasis has been on drawing upon the urban setting of New York to study local environments and their economic and social dimensions. This study has been effective as a way to facilitate both a connection to the environmental challenges of the places we inhabit and might have the most meaningful connections to and as a methodology for making connections to similar environmental issues on a broader scale. Through this process students begin to establish a deeper connection to the power of observation as a tool for understanding and transforming urban environments.

5.1 The Virtual Study of Place

Many of the benefits of virtual learning environments that have been cited in recent studies have a direct application to mapping and visualization of environmental data. One important benefit is that virtual exploration can be employed as a tool that can both enhance the study of physical space and make that space accessible in cases where direct observation is not possible. Zumbach et al., for instance, note that the use of computer-based learning environments in general and computer-based simulations can be used effectively to offer a first-hand experience that is authentic and meaningful in situations where direct experience is inaccessible, such as the lack of laboratory facilities to conduct experimental research.[1]

However, beyond simply constituting a way to overcome limitations on direct access to a physical location, the virtual experience can in many ways add an important dimension to the learning process, making possible the development of a new perspective on place. Here, the virtual study of place can enhance and complement the physical exploration by bringing students together in a shared experience. Iqbal et al., for instance, maintain that virtual worlds “are essentially social in nature” facilitating a collaborative environment, and that virtual place-based learning can facilitate a range of learning strategies that can be facilitated through virtual place-based learning, including project-based, inquiry-based, and experimental learning. At the same time, the virtual experience enhances communication and interaction among users.[2]

The inclusion of the virtual technique has been employed in a varied array of learning environments and within a diverse number of disciplines, creatively expanding upon the experience of place. In this way, virtual place can both *enhance* the study of physical space and overcome the limitations of access by enabling study in urban environments where physical observation of particular places is limited. Through this practice, the resources of urban settings can be cultivated in designing virtual methodologies, and the experience of place can be realized as geographic place, while other limitations of physical space are transcended. An interesting example can be found in the innovative application of virtual mapping in Ung et al. in which the authors mapped the distribution of air pollutants over the city of Strasbourg. By creating a virtual measuring station that gauges atmospheric pollution through a remote sensing methodology, the authors were able to overcome some of the limitations of physical measuring stations, such as the costs of maintenance, while capturing a measure of "the spatial distribution of atmospheric pollutants."[3]

Virtual learning environments also have the advantage of employing methodologies that help in bridging the gap between formal and informal learning processes, while at the same time enhancing learning, creating a setting that "gives learners a sense of being in a place with others," and enabling the visualization of the unobservable.[4]

A further benefit of the virtual learning environment is its interactive feature, wherein users of a particular technology are not merely receiving but influencing and transforming it in the process. This view is highlighted in Jones et al. who have envisioned virtual learning as a methodology that can address a variety of needs, is accessible, and can be used and shaped by users.[5]

Lamb and Johnson specifically consider the value of geo-visualization tools in teaching—GIS in combination with web-based technologies—in making geographic information increasingly accessible and in using that information to create and enhance maps. In highlighting the applicability and advantages of geo-visualization to problem solving inquiry, the authors note users' ability to identify, collect, and analyze data, and then using that information to address environmental issues "such as determining the environmental impact of a new coal power plant or predicting the spread of wolves introduced to a particular region."[6] The mapping project facilitates many of these strengths of the virtual learning environment.

5.2 Design of the Mapping Project

The mapping project was introduced as a technique for exploring environmental themes and issues from a *virtual* perspective—as a way to engage in the study of place through the examination and mapping of environmental data. The project is centered on having students first identify an environmental theme or issue they are interested in researching. Examples might include exploring the relationship between the locations of hazardous materials disposal sites and the incidence of respiratory conditions; studying the transformation of a particular place over time in conjunction with a changing economy (i.e., from industrial to green space); or mapping the growth of farmers markets throughout the city or the location of green roofs and examining how these transform local economies and environments.

Students then start by conducting some preliminary research to determine what kind of data would be helpful in developing a better understanding of their chosen topic. The open data sources used in the project enable students to develop either a local or statewide environmental focus for their project. This is designed to encourage a familiarity with local issues. As this exercise is entirely web-based, the goal of this assignment is to integrate existing familiarity with the urban landscape with an exploration of a local environmental initiative or problem within that environment that students may not necessarily have had prior familiarity with.

One class session is dedicated to an introduction to mapping and a review of some key open sources of environmental data, including NYC Open Data, NYS Open Data, and NYS Open Health Data. Working through a practice dataset detailing the location of and types of noise complaints called into New York City's 311 hotline, students are taken through the steps involved in how to identify geocoded data that can be represented in a map, as well as how to filter, export, and save the data using file types that are compatible with the mapping program. Students then set up individual *Carto* accounts and are introduced to the concept of representing and analyzing data in a map. The program's highlights, features, and capabilities are highlighted as students work with the sample 311 data. In this practice session, students use the sample data as they are taken through the steps of identifying the type of files that can be mapped, downloading and importing data files into *Carto*, and creating, styling, and adding legends to their maps (Fig. 5.1).

Once students have worked through the steps involved in identifying, filtering, and saving data, they are assigned time to begin exploring these open data sources and identifying datasets they might be interested in working with and studying further for the mapping project. In the process, students are encouraged to work in teams of two or three based on shared interests. An important next step involves making key connections between the data that has been selected and mapped and the larger social, economic, and environmental context that gives meaning to the data. In the process of conducting further research, the goal is for students to

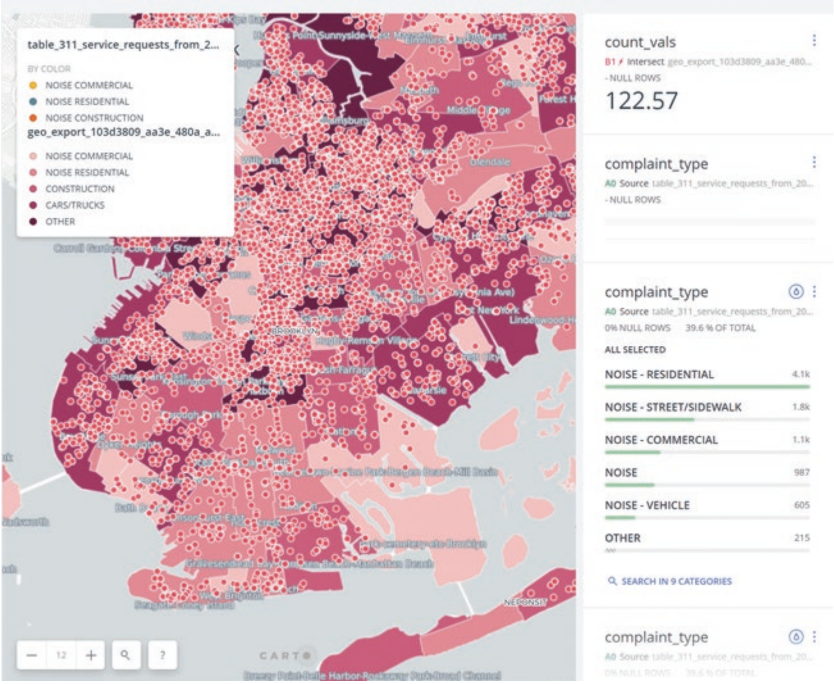

Fig. 5.1 Screenshot of a mapping application in *Carto*

uncover the story behind their data. In a two-page research summary, students discuss what their selected data shows, what they view as its environmental significance, the particular environmental challenge or problem it points to, and who or what the condition impacts. Finally, they consider the kinds of remediation that are recommended to address the problem and summarize the specific conclusions they have drawn from the project.

Through this exercise, students' attention is focused on making important connections to the theme of the course: promoting sustainable economic growth through efficiencies in technology, planning, policy design, and the re-shaping of social and economic priorities, while incorporating the goals of social, health, economic, and environmental justice. At the same time, it explores how economic priorities can be effectively applied to the goals of slowing global climate change and advancing sustainable economic development.

In the course, the sense of place is defined and referenced through the focus on the urban setting of New York City. Through the process of representing environmental data using a mapping program, students are able to engage in a virtual exploration of place and its environmental characteristics and challenges. Once that data is placed in the map, the visualization prompts the exploration of further questions: how did this particular geographic area come to be the locus for this environmental trend or problem? What have been the economic and environmental impacts on the affected community?

Once students have decided on a topic, their work in "observing" the environmental phenomena that are at the center of their research involves researching the larger environmental story their data points to. What is the social, economic, and historical context? What urban communities are impacted by decisions that might have a clear environmental, economic, or health outcome? Given what the data points to, in what ways have they sought to shape or re-shape outcomes? In representing data in a map, what phenomena are observable? What conclusions can be drawn? Through this research process, the sense of place is observed and accessed virtually as students become familiar with the tangible implications and significance as their mapped data brings to life the real-world environmental challenge, issue, or problem.

In this context, students explore who the key decision makers are who shape economic and environmental outcomes in particular settings. By accessing place virtually in this exercise, students' exploration of a specific geographic area within the urban setting offers the opportunity for them to develop a greater familiarity with the relationship of current environmental issues to life in their own surroundings. The following discussion highlights examples of projects that students designed and explored using Open Data sources and Carto. In these projects, students also make important connections to the interdisciplinary perspective on the data and the story surrounding it.

The discussion that follows highlights two examples of students' mapping and visualization projects, including screenshots of their maps in *Carto*. In the first example, students examined data and supporting research on the relationship of asthma incidence rates and the physical proximity of residential areas to waste transfer sites. In the second instance, a team of students mapped complaints about indoor environmental conditions.

5.2.1 Student Project: Asthma Incidence and Waste Disposal Sites

One team of students, examining NYS Open Health Data, sought to understand the relationship between respiratory illnesses, air pollution, and economic costs. For this project, the students accessed data that identified concentrations of airborne pollutants across each of the state's counties, together with a corresponding dataset that identified asthma-related emergency room visit rates at the county level. They began by creating a map indicating the county-level asthma emergency room visits, employing this as a close indicator of county-level asthma rates and related health problems.

With the data pointing to the Bronx as having one of the state's highest rates of asthma-related emergency room visits, the students then began investigating. Their initial analysis pointed to a rate that was twice that of the City overall and even greater relative to geographically closer suburban upstate counties. Further inquiry led to the discovery that several busy waste transfer stations were located close to many densely populated residential areas. At the same time, they uncovered findings of high levels of airborne pollutants linked to the heavy truck traffic on roads and highways adjacent to nearby schools and many of the same residential areas. Their research then led them to the South Bronx Environmental Health and Policy Study[7] and its findings linking health outcomes to obsolete industrial sites, a sludge processing plant, as well as the waste transfer stations and high traffic congestion located in close proximity to densely populated residential areas.

The toxic sites, along with the major roadways and highways, were mapped, together with the asthma incidence data in *Carto*. Connecting this environmental data on the map to the issues of poor health outcomes and its environmental and economic costs allowed the students to present a story that highlighted the social, economic, and historical contexts. This presentation of a critical analysis was able to make the important connection between the collection and presentation of data and its interpretation and meaning (Fig. 5.2).

At the same time, the study made an important connection to the environmental justice movement, highlighting local community efforts to become informed about the location of the sites, to understand the connections between exposure to the fumes and toxins and health problems, and the organizing efforts to have the sites closed or relocated. In this way,

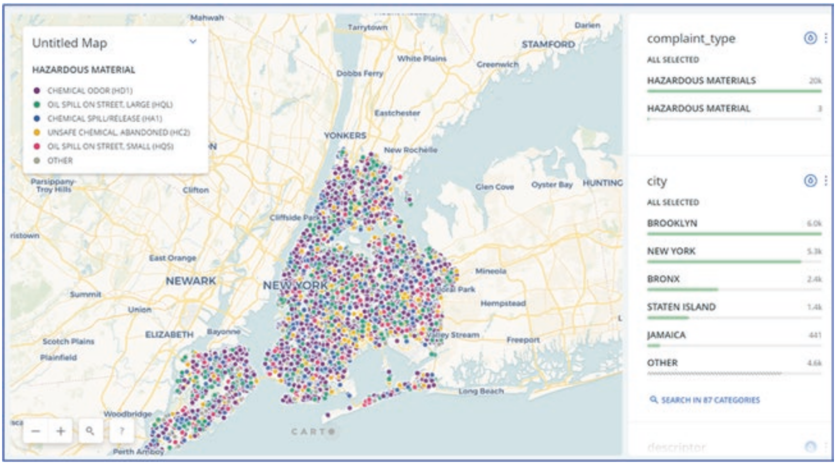

Fig. 5.2 A screenshot of students' project mapping types and locations of common hazardous material sites in New York City

the students demonstrated how data—and how gaining access to it—can be a vital source of community empowerment—organizing to force the closing and relocation of toxic sites to non-residential areas.

5.2.2 *Student Project: Indoor Air Quality Complaints*

In another example, a group of students examined indoor environmental complaints using open data available from the New York City Department of Health and Mental Hygiene. The data on the site, available at the county level, are compiled from complaints called into the City's 311 complaint system and include incidents reported by occupants in both residential and commercial buildings. In their study, the students first determined that complaints could be broadly categorized under issues of indoor air quality, indoor sewage, asbestos, and "other." These categories were then mapped to create a visual presentation of their concentration and location across each of the City's five boroughs.

The students then conducted research that illuminated some of the potential health effects associated with exposure to the indoor air pollutants they identified from the data. Among the most serious potential health outcomes were asthma, various allergic reactions, asbestosis, bronchitis, and other respiratory problems. A central focus of the course is the importance of examining the economic *as well as* the environmental costs of environmental problem. In this project, students looked at estimates of the health costs associated with indoor air quality complaints and data pointing to the costs of treatment.

The next step involved an exploration of possible remedies, including existing federal, state, and local environmental regulations and how these can be more effectively enforced in both residential and commercial office buildings through information and education campaigns. They also pointed to the Asthma Free Housing Act, a recently enacted City regulation requiring landlords to work to maintain housing units free of problems known to be associated with asthma incidence, including vermin and mold.

A final component of the mapping projects involves students' preparation of a two-page summary in which they describe the data they chose and detail their interest in selecting the particular topic and data. In their discussion of the environmental significance of their mapped data, students are asked to address the questions of what kinds of problems the data point to, and what, if any, forms of remediation were implemented, or what actions are recommended to address the issue. In the summary, students are also asked to consider what factors they would consider in assessing the economic costs and to reflect on the benefit of the project in learning about local environmental issues and their significance on a broader scale beyond the local geographic area they have focused on.

5.3 Reflections on the Project

In each of these projects, the ability to picture the environmental topic being researched facilitated students' ability to place it within a larger social and economic context. In this way, the visualization exercise helps to transform the project from abstraction to real-world context. This virtual exploration of place can be transformative in a number of ways. The examination and mapping of environmental data illustrated in this discussion makes possible a form of visualization that facilitates access to physical place while enhancing an understanding of the dimensions and complexities of the physical place. In this way, the exercise enables the use of mapping as story-telling, as the project helps give voice to important issues faced by urban communities and to their efforts to address environmental hazards. Through the virtual access to place, the environmental, economic, and historical contexts become accessible, enabling students to further connect to the interdisciplinary theme of the course.

Similarly, the process of conducting research illuminates and gives context to the larger environmental picture. In being able to visualize their data and the environmental problems it illustrates students are able to think about how the information can be used to change outcomes on a larger scale. In representing data on a map, the observation and study of place is realized as students are able to visualize the tangible implications and significance of their mapped data, and in the process, bring to life the real-world environmental challenge. In this context, students become familiar with the key decision makers who shape economic and environmental outcomes in particular settings.

Finally, the virtual study of place, which gives students the means to explore a specific geographic area within the urban setting provides the opportunity for them to develop a greater familiarity with the relationship of current environmental issues to life in their own surroundings.

5.4 Conclusion

How can educators at other institutions adopt a similar virtual place-based learning application/exercise? Why/how would this be effective in other/their locations? Urban spaces in any number of locations offer the opportunity to link the study of a particular problem or issue to the real-world experience of that problem using a virtual place-based approach. The key is thinking creatively about how to employ resources offered in the virtual environment as a laboratory that students can explore as part of the process of working toward a fuller understanding of the way a research topic/question takes shape in the real world. In this way, students' understanding of research questions can be deepened through the added knowledge gained about how that challenge plays out in the actual laboratory of the larger community.

There are now several freely available mapping applications that can be employed to import and visualize data on a broad range of topics and issues.[8] As of this writing however, *Carto* is no longer publicly available.

The increasing availability of a range of open data and mapping resources does not simply facilitate *overcoming* the limitations of physical access to place. It clearly has the benefit of significantly *enhancing* the exploration of place. Incorporation of a virtual, place-based learning experience in student research also has important socio-economic implications.

Limitations posed by socio-economic circumstances that make direct observation unfeasible can be surmounted through a virtual experience. The incorporation of a virtual engagement with place can serve to enhance the process of meaningfully connecting under-represented groups in urban environments, successfully bringing the real world to students in urban settings, while at the same time integrating an interdisciplinary perspective on that world. The virtual study of environments similarly facilitates the examination of the impact of events as they unfold, broadening the concept of community and making place-based study accessible almost anywhere.

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There are also numerous open data sources including FiveThirtyEight (https://data.fivethirtyeight.com), Data.gov (https://www.data.gov), and Tableau Datasets (https://community.tableau.com/docs/DOC-10635), each of which provide links to dozens of sites with publicly available data such as the US Census Bureau, US Department of Agriculture, the World Bank, and data collected and published by other nations.

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CHAPTER 6

Mapping Urban Performance Culture: A Common Ground for Architecture and Theater

Ting Chin and Christopher Swift

Abstract Our co-taught course focuses on theater history, with an emphasis on performance architecture. Assignments are designed to illuminate the ways in which architectural design and technology inform performance practices and audience reception. The pivotal assignment for exploring interdisciplinarity is a three-week module on mapping historical theaters in New York City. Open-source Global Information Systems (GIS) software serves as a common mechanism for students to situate theatrical productions in the context of the built urban environment, deepening their understanding of the social, economic, and artistic forces that contributed to performance culture. Mapping is a shared pedagogy for analyzing and presenting research findings from different fields. Learning how to collect, analyze, and map data is also a general education skill that can be applied to disciplines across undergraduate curricula.

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This chapter focuses on the utilization of digital mapping in an undergraduate interdisciplinary course at a public urban university, the New York City College of Technology (City Tech). In the course *History of the Theatre: Stages and Technology*, digital mapping facilitates collaborative pedagogy for analyzing and presenting research findings on New York City urban geography, environment, and history. Guided by co-instructors from architecture and performance history, *History of the Theatre* explores the intersections of architecture and theater from Ancient Greece to the present moment. The central assignment in the course is a scaffolded semester-long research project on historical theater buildings in New York City. The project incorporates digital map-making to facilitate research into the social and cultural forces that shape theatrical production and architectural design in the urban milieu.

In the first stages of the assignment, students research production histories and architectural design elements of existing theater structures, fostering the development of archival research aptitudes and place-based observation and documentation skills. The assignment culminates in a virtual place-based study using Global Information Systems (GIS) mapping: using georeferenced data and mapping software, students situate the theater within the context of local economic, social, and physical features. GIS mapping software is used to access, analyze, and graphically represent layers of data and, as applied in our course, supports virtual place-based research. Learning how to present and interpret data with digital mapping applications supports general education outcomes and can be incorporated into a variety of disciplines across the undergraduate curriculum. As a virtual place-based application, digital mapping offers "ground upon which humanities scholars can collaborate with investigators engaged in scientific and quantitatively-oriented research."[1]

The chapter begins with a discussion of the value of virtual place-based learning in the context of interdisciplinarity and general education. Next, we provide a description of a digital mapping research project, structured to facilitate collaborative, problem-based inquiry with the use of digital tools. Finally, we describe the manner in which materials are presented during the semester and provide examples of student work.

6.1 The Value of Virtual Place-Based Learning in Interdisciplinary Teaching

There are myriad ways digital interfaces have empowered humanistic inquiry and literacy. The challenge for humanities educators is to conceive of ways to integrate digital technologies without requiring advanced knowledge of computer engineering and coding. Examples of such applications are the online mapping tools ArcGIS (ESRI), QGIS, and GeoDa, whose basic functions can be taught in one or two classroom sessions. As a method of investigation through the virtual production of place, digital mapping offers a powerful means for interdisciplinary work among English, history, theater, geography, economics, urban studies, architecture, sociology, cultural studies, and other disciplines.

Literature on place-based pedagogy is extensive but virtual placed-based learning is less studied. Place-based learning has been interpreted in many ways but can be summarized as being "concerned with context and the value of learning from and nurturing specific places, communities, or regions."[2] Most descriptions of place-based learning include the shared pedagogical approach of using local communities as laboratories for inquiry-led, problem-based, active learning. Descriptions of virtual place-based learning vary more widely and have been described as anything from the design of virtual learning environments to digital game-based assignments. In *History of the Theatre*, virtual place-based learning involves GIS mapping to conduct in-depth research on urban architecture, infrastructure, culture, and audiences in New York City. Students begin with a research assignment following traditional methods of place-based pedagogy and then broaden their research subjects in virtual space, using geo-referenced data and digital mapping software. In-person observation allows students to investigate and experience environments, communities, institutions, and works of art through multiple senses and modalities, while virtual geographic domains enable the integration of quantitative data in research projects. Additionally, digitized images and maps are available in open repositories and can be embedded in virtual environments to produce a fuller sense of place and materiality.

GIS mapping is a powerful computer application that translates complex data into simple graphic terms, and in the general education setting, provides a learning tool that can be used in many undergraduate courses across humanities and technology fields. It is a high-impact pedagogy, providing creative, interactive methods for visualizing complex quantitative information in tangible and compelling ways.[3] GIS mapping can project layers of demographic, historical, and environmental information that concretizes abstract thought and produces spatial narratives that "provide rich connotations and attachments to the humanities' storied-narrative style."[4] Because GIS mapping has the ability to graphically represent and juxtapose many types of data, it is an inherently interdisciplinary tool that, when used in classrooms, fosters an understanding of the relationships between distinct areas of study.

In the context of a college of technology, our course aims to promote consideration of the human forces that contribute to the construction of the urban environment and, conversely, how spatial representations and designed places inform social interaction and cultural production. More broadly, we teach cultural history through an interdisciplinary engagement with data science and technology, underscoring the interconnectivity of quantitative knowledge and theory, data and interpretation. Historically speaking, as an expression of empirical space among layers of imagination and ideology, map-making is an activity that resides at the intersection of the arts and sciences.[5] Digital mapping provides even greater capacities for intersections between informative and creative knowledge since in cyberspace "time and space themselves are malleable constructs. It is possible, for example, to locate the virtual learning environment in a time period other than the present—a historically significant period as called for by a course in archeology, or one which has not yet been constructed for a course in architecture."[6] In other words, while maps are utilitarian and informative, they also exhibit perspectives and culturally specific ways of seeing the world. Through the act of data collection, reorganization, and design, students learn a valuable lesson about the interpretation of evidence. Documentation and memorialization are processes of selection—restoration and removal, remembering and forgetting—and part of an ongoing production of contemporary culture.

6.2 Virtual Place-Based Learning in an Interdisciplinary Course in Theater History

History of the Theatre is offered by the Humanities Department at City Tech and fulfills a general education requirement for all students at the college, which means that students who register for the course come from a wide range of backgrounds and possess disparate aptitudes. The backbone of the course is a chronological survey of major theater movements in the West from the Greeks to the present. Unlike many other undergraduate theater history courses, *History of the Theatre* does not include the study of plays (directly) or biographical information about artists, partly because the three-credit course is taught in one semester. Rather, the syllabus focuses only on physical stages and performance technologies, which has facilitated meaningful avenues for cross-curricular conversations between the departments of Humanities and Architectural Technology. Although City Tech does not offer a degree in theater, the course is a requirement for a bachelor's degree in entertainment technology, and architectural technology majors commonly register for the course. The majority of the students at our college of technology are enrolled in STEM and professional studies majors and have had little exposure to the performing arts. The interdisciplinary approach to theater history offered in this course provides a pathway to the arts that might not otherwise exist.

The semester-long scaffolded GIS mapping project on New York City theater architecture, production, and audiences accounts for approximately 25 percent of the overall grade for the course. As a city rich in historical and contemporary theatrical traditions, and the place where our students live, study, and work, New York City is a living archive that offers unparalleled opportunities for place-based learning. Before initiating research for the mapping project, students learn about the historical development of theater and architecture in the city from the nineteenth century to the present, concentrating on the ways in which economics, immigration, and urban development and infrastructure shaped the formation of performance cultures in New York City. Lectures and readings are supplemented with backstage tours of theaters such as the Harvey Theater at the Brooklyn Academy of Music, Joseph Papp's Public Theater, and the Samuel Friedman on Broadway. These activities provide a historical foundation and environmental scan of contemporary performance culture that will inform subsequent research and the development of GIS maps. Students are also taught basic skills in bibliography, image attribution, data mining and spreadsheets, and digital mapping prior to commencing work on the project.

GIS data collection and mapping are used to creatively and critically engage students using sets of data, archival material, and digital media to discover connections between performance culture and the built environment. Architects, city planners, developers, and municipal agencies all conduct site analyses prior to embarking on the design of any construction project. The importance of these kinds of studies is presented to students as a way of introducing the multiplicity of factors that contribute to the design of the urban landscape. The act of mapping data relevant to a theater's urban context, such as adjacent building typologies, land use, zoning, location of transportation and municipal infrastructure, and demographics helps students perceive theatrical activity and spatial design as outcomes of social, esthetic, and technological forces. Robert Summerby-Murray writes of a similar approach used in the study of historic buildings in a geography course:

> The emphasis in this approach is not on the use of GIS technologies as a mechanistic tool or on the technicalities of software design, innovation and modification but rather on the scientific inquiry processes by which geographic phenomena are measured, generalised, analysed and represented and how these processes are sharpened through the use of GIS technologies.[7]

In *History of the Theatre*, students are introduced to GIS as a tool to graphically represent and analyze layers of data in order to gain a deeper understanding of performance culture in an urban community.

6.3 DESCRIPTION OF GIS RESEARCH PROJECT

The scaffolded research and mapping assignment progresses in three stages. Initial engagement with the physical, living archive of historical performance spaces lays the groundwork for the further articulation of place in the virtual environment of GIS mapping. Students engage with the urban archive by visiting existing theater buildings where they sketch, take photographs, read documents from physical archives, and learn from theater managers and other practitioners. Next, research continues in digital archives and databases. Students use virtual mapping to investigate the surrounding neighborhoods in order to make meaningful connections between theatrical production and reception. Lastly, students conduct analyses and convey their findings in formal classroom presentations. We have designed the project to give entertainment and architecture technology students mentorship opportunities with students from other disciplines. In small group activities, discipline-specific knowledge from theater and architecture is reiterated through peer-to-peer interactions.

6.3.1 Stage 1: Place-Based Research

Working in teams of two or three, students select an active theater to research. The instructors provide a list of theaters that are architecturally significant (e.g., the Signature Theater, designed by Frank Gehry), represent an innovative reuse of a preexisting structure (e.g., St. Ann's Warehouse, a repurposed eighteenth-century tobacco warehouse), or are historically meaningful (e.g., Lowe's King's Theater, an early twentieth-century vaudeville and photoplay theater). Student teams conduct place-based research by attending a performance at the theater and documenting their observations with hand sketches, photographs, and written notes. A list of research questions encourages careful examination of the practical and decorative features of the facade, audience spaces, and stages:

> *How does the building relate to its physical surroundings? What are notable features on the facade? Discuss the semiotics of place: what impressions do the design elements make and how do they shape expectations about the performance? Describe decorative and practical elements in the auditorium and other audience spaces: lighting, balconies, lounges, aisles, etc. How is the seating arranged in respect to the performance space(s)? Is the stage a thrust, arena, or proscenium type? What is the acoustic quality of the space? What kinds of technologies are available to support the performance (amplification, projection, etc.)? Finally, describe how these various aspects supported, enhanced, informed, or detracted from your experience as an audience member.*

Having an architecture or entertainment technology student embedded in each team proves advantageous for these site visits. Site observation and documentation is a typical skill taught in architecture curricula so architectural technology students can help others who may be less adept at hand sketching. Entertainment technology students can point to stage structures and equipment that were discussed in class. After the place-based interrogation of the site, teams then conduct research in primary and secondary sources that deepen their understanding of the theater building. A series of prompts guides their research:

> *When was the theater building constructed and for what use? Who were the architects? If it is a purpose-built theater, what kinds of plays were first performed there? If it is a converted space, what was the original use of the building and when was it converted? What changes did the architects have to make*

> *to adapt the building so it could be used as a theater? Today, what is the artistic mission of the resident company or producing directors? Is the theater a non-profit or for-profit house? What kinds of plays or musicals do they present, and for what kinds of audiences?*

With their written responses to the above prompts, students submit an annotated bibliography, photographs (with Creative Commons attribution), and sketches. This first stage of the project is due around the middle of the semester. Stage 1 of the assignment provides an opportunity to teach students how to conduct place-based research through attentive firsthand witnessing and documentation of the primary source (the theater, the production), and then supplementing their understanding of the place with secondary sources. This establishes a foundation of knowledge for a virtual exploration of place.

6.3.2 Stage 2: Virtual Place-Based Research

In the second stage of the project, teams of students conduct research in open digital archives on the neighborhoods in which their subject theater is located. They project this georeferenced data onto a digital map in graphic form. Data mining and storage, and software integration and application, are taught in three class periods over a six-week period, which allows time for students to familiarize themselves with the software and work collaboratively outside of the classroom designing their maps.[8] The objective of this stage is to provide an activity that demonstrates to students how cultural production (by artists, technicians, and producers) is inherently intertwined with cultural consumption (by audiences). Students also learn how urban planning and infrastructure shape the geography and economics of theatrical production.

Students are given a hypothetical scenario modeled on professional concerns in urban planning and development and are asked to use georeferenced data to conduct an analysis of community demographics, urban infrastructure, and zoning:

> *You have been hired to conduct an analysis of the demographics, urban infrastructure, and land use of the neighborhood of your theater. The theater company aims to produce shows that will attract local audiences. They also want to understand urban infrastructure that will facilitate access to the theater. What types of information would help the company understand their community best?*

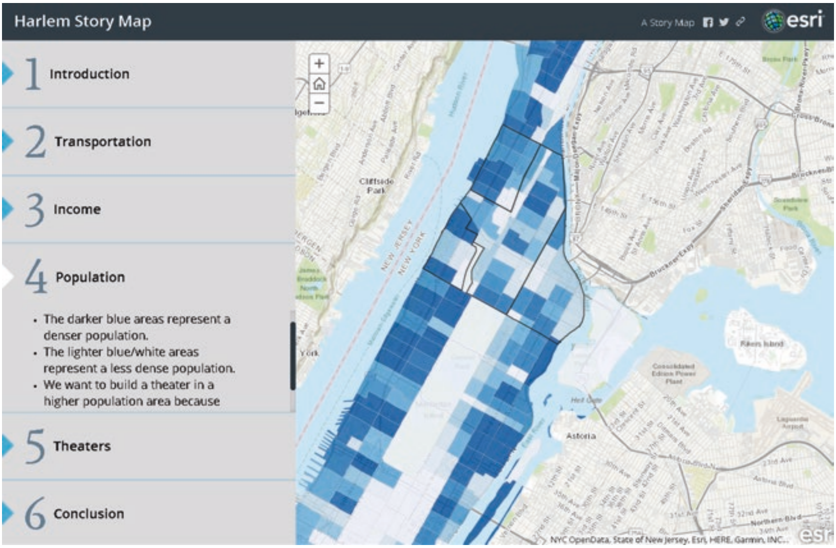
> *What conditions prevent or encourage access to the theatre? Describe the target audience: who would be served by the theater? What kinds of plays and entertainment would attract the local community?*
>
> *In order to answer these questions, gather data on the following:*
>
> - *Population density and demographics of residents, commuters, and tourists.*
> - *Infrastructure (public transportation, parking, sidewalks, and thoroughfares).*
> - *Local zoning ordinances, building typologies, and land use.*
> - *Crime and noise pollution.*

Students are introduced to open data available from federal, municipal, and private archives. In many cases, this information has already been georeferenced in .CSV file format so that it can be read and projected onto virtual maps with mapping software. Demographic information is available from census data, and land use and local building information may be available from city and local planning offices, such as NYC Open Data. Datasets that have been gathered by users of ESRI's GIS software are available through the ESRI portal. New York State's Freedom of Information law and Commission on Public Information and Communication has facilitated the liberation of vast amounts of data on city demographics, crime, housing, and environmental issues. Additionally, the city maintains several mapping tools through the NYC.gov portal, such as *NYC Map*,[9] built upon countless points of informative data. Released in 2013 by the Department of City Planning, *PLUTO*[10] is another ever-expanding database containing extensive land use and geographical data used by researchers, developers, community organizations, and students for understanding economic, housing, health, and safety conditions at the local level. Given the large amount of data available online about New York City, it is necessary for instructors to provide guidance on how to locate, upload, and organize the data. While federal and municipal sources are generally reliable, data needs to be evaluated for accuracy. Students are taught how to locate data that is up-to-date, comprehensive, and relevant to their research.

As they navigate these various databases, some students collect demographic information to assess taste in theatrical forms. Throughout the semester, we discuss how economic and social class and cultural tastes are intertwined. In particular, we follow the trajectory of Shakespearean drama, classical opera, and melodrama as they are produced and experienced in different historical periods and communities, and how production and reception reflect the aspirations and tastes of audiences. In the following example of a student project, demographic data lead to the team's conclusion that new plays developed in educational outreach programs would be a viable approach to production. Their map of upper Manhattan showed a dense and predominantly low- to middle-income population. The team argued that a nonprofit community theater could support emerging artists and employ young adults, which could lead to the development of a cultural center and job opportunities for local residents (Fig. 6.1).

In the presentation of their material, the team compared their vision with the historical theater community of the Harlem Renaissance, a topic of study earlier in the semester.

Students also gather information on commercial and theatrical activity in an area in order to evaluate potential audiences. In a project focused on midtown Manhattan, research revealed intensive commercial activity and a population of high-income residents. In their analysis, the team was able to unpack the relationship between the high-brow culture of Lincoln



- The darker blue areas represent a denser population.
- The lighter blue/white areas represent a less dense population.
- We want to build a theater in a higher population area because

Fig. 6.1 "Harlem Story Map," Li Pan and Trisha Pham, https://arcg.is/0rXLfG

Center for the Performing Arts and the retail activity in the neighborhood. This led to an in-class conversation about the changes to the neighborhood since the construction of Lincoln Center in the 1960s and how that municipal project effectuated major changes to the urban landscape, including the displacement of Hispanic and black communities (Fig. 6.2).

Once the teams of students have collected data that will appropriately answer the research questions listed above, they are taught how to conduct basic functions in the online version of the mapping application ArcGIS. ArcGIS is used in this course because it easily integrates with two of the larger resources for open data, ESRI Open Data and ESRI Living Atlas. The online version is particularly useful for collaboration among team members since it can be accessed by any computer with an internet connection. Also, City Tech has an institutional license to operate the professional version of the software allowing more advanced architectural technology students to build more sophisticated interactive maps.

Once students are able to comfortably validate and import relevant sources of data, they are taught different options for graphically representing data drawn from open databases. Since the amount of georeferenced

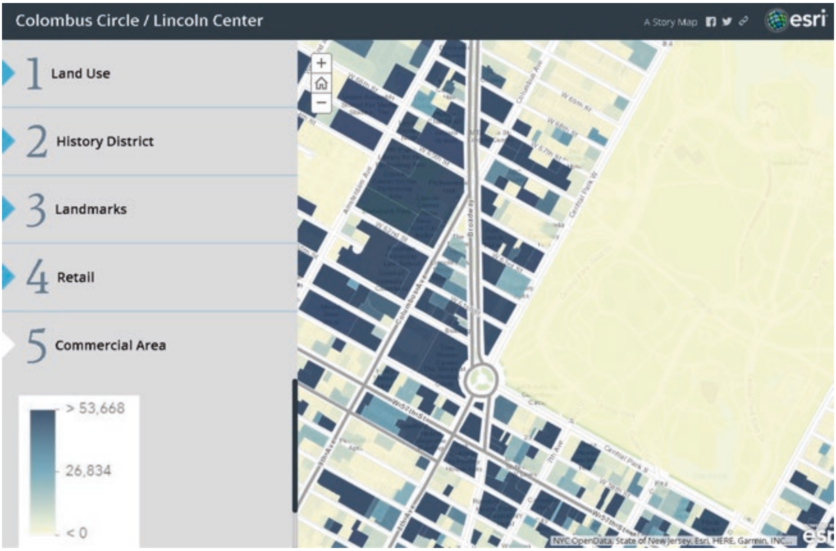


Fig. 6.2 “Columbus Circle/Lincoln Center,” Flore Cadet and Areli Amado, https://arcg.is/Sf8HK

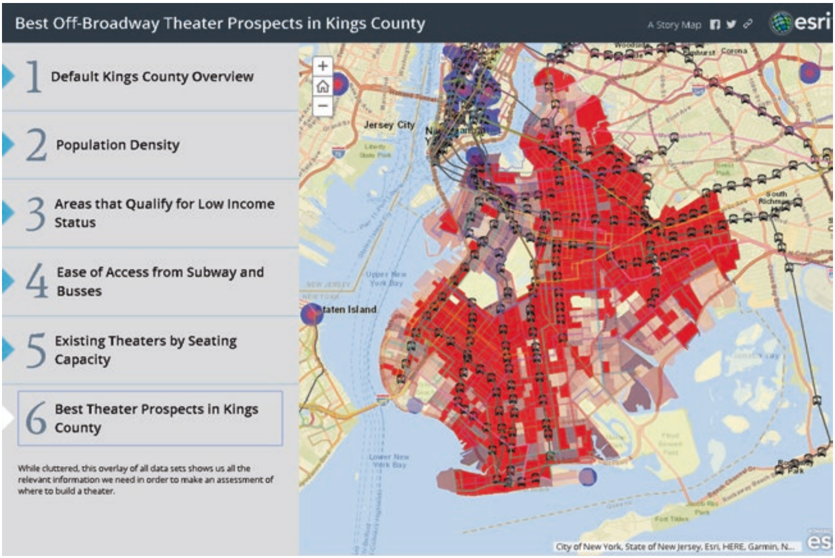
information on the internet is overwhelming, students are shown how to curate the data, evaluating for relevance and reliability in particular. We provide a general review of data visualization in various fields such as the environmental and social sciences, geography, and history in order to show a range of methodologies for representing abstract information. As the notable scholar and expert on data visualization Edward Tufte writes,

> [a]t their best, graphics are instruments for reasoning about quantitative information. Often the most effective way to describe, explore, and summarize a set of numbers—even a very large set—is to look at pictures of those numbers. Furthermore, of all methods for analyzing and communicating statistical information, well-designed data graphics are usually the simplest and at the same time the most powerful.[11]

Most GIS mapping applications allow users to adjust colors and transparency of mapping areas and vectors, and create add-ons like legends and timelines to maximize the impact and highlight specific data fields. Students are shown how to operate these functions and are critiqued on the graphic legibility of information in their presentations. Students are tasked with creating a minimum of five graphic displays of their data that represent the urban artifacts and conditions of their assigned neighborhoods.

6.3.3 Stage 3: Summary, Analysis, and Presentation

At the end of the semester, student teams conduct formal presentations of their findings in class. In these presentations, they describe local audiences, the degree of access to the neighborhood, and draw conclusions about the kinds of productions that would best address the preferences of local communities. ArcGIS StoryMaps is introduced as a tool that allows users to import maps created in ArcGIS into a slideshow that combines textual narrative, visual content, and interactive features (timelines, zooming, pop-up windows, animation, etc.). For each slide containing a map, students are asked to include narrative text that describes the data and graphic overlays, provide citations to sources, and to articulate orally why the data is relevant to their study. They must conclude by summarizing how all the different pieces of data cumulatively informed their responses to the queries of the hypothetical theater producers. In the following example of student work, a comparative analysis of different data sets informed the recommendation of a location in Brooklyn for a new theater.



Best Off-Broadway Theater Prospects in Kings County

1 Default Kings County Overview

2 Population Density

3 Areas that Qualify for Low Income Status

4 Ease of Access from Subway and Busses

5 Existing Theaters by Seating Capacity

6 Best Theater Prospects in Kings County

While cluttered, this overlay of all data sets shows us all the relevant information we need in order to make an assessment of where to build a theater.

Fig. 6.3 “Best New Theater Prospects in Kings County,” Robert Helle, https://arcg.is/15HP9f

The student created a map with layers of information on transportation access, population density, income levels, and the locations of existing theaters. Using this map, he was able to cross-reference fields of data to identify the most viable area for the construction of the new theater. The determination was based on ease of access, the lack of competition from other theaters, and the presence of middle- and high-income populations that could support a commercial venture (Fig. 6.3).

6.4 FURTHER SUGGESTIONS AND CONCLUSION

The GIS mapping assignment has been an effective means of teaching how social and material conditions in an urban environment inform the design and construction of performance spaces while also introducing a digital communication skill for virtual place-based research. Students have been able to find, analyze, and visually represent relevant data across disciplines in order to formulate well-reasoned conclusions. Building teams of students from different disciplines was particularly useful in facilitating mentorship and peer-to-peer learning opportunities. The project covers a wide array of skills and materials that may be unfamiliar to many students in an interdisciplinary class, so it was designed in such a way to capitalize on the variety of skill sets that students bring to the class, including data collection and organization, practical knowledge about theaters, and familiarity with computer applications, graphics, and drawing. Positive student interactions outside of class resulted in the accumulation of shared knowledge which was often demonstrated in their final presentations. These collaborations fostered a collegial atmosphere and contributed to the success of projects.

Employing GIS mapping as a tool to conduct virtual place-based learning can be applied in disciplines such as English, history, and economics, as well as other seemingly exclusive domains. Teaching how to analyze and interpret illustrated data can be applied to almost any learning outcome involving geography or spatial narrative. Before embarking on the design of a teaching module based in GIS mapping, instructors should conduct a review of publicly accessible data in order to ensure that relevant information is available in open archives, and that it has been georeferenced, so that it can be easily used in classrooms. As discussed above, there are also benefits to focusing assignments on local communities to allow for integrated research between virtual place-based and embodied place-based modalities.

GIS mapping and data research is a powerful method of problem-based inquiry in technological and humanities disciplines. It is a pedagogy for analyzing and presenting research findings at the intersection of different fields, fostering collaborative learning. Digital mapping can be used as the shared mechanism for students from different backgrounds to situate research questions in the context of the built urban environment, deepening their understanding of the forces affecting the conditions of neighborhoods and communities. Teaching students to collect, visualize, and analyze data can be applied across undergraduate curricula and used as a way of identifying common ground.

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CHAPTER 7

Using Virtual Reality as a Tool for Field-Based Learning in the Earth Sciences

Stephen M. J. Moysey and Kelly B. Lazar

Abstract Field experiences play a critical role in Earth Science education but are typically difficult to offer to all students taking introductory Earth Science courses. Virtual reality (VR) may be a pathway to overcome the barriers of a traditional field experience by simulating interactions with the natural environment and providing opportunities for students to develop their observation and problem-solving skills. Presence, interactivity, and accessibility of a virtual field experience are suggested factors impacting achievement of the geoscience learning benefits of affect, cognition, professional development, and inquiry. Careful consideration of the affordances of different VR modalities, from photospheres to immersive worlds, can enable diverse opportunities for virtual field experiences, meeting the learning needs for a wide range of settings and students.

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The importance of field experiences for recruiting, retaining, and training students in the geosciences is well known.[1] A field trip to the Grand Canyon, for example, would allow students to explore almost 2 billion years of geologic evidence for the depositional, erosional, and tectonic transformations that continuously shape the Earth's surface.[2] Such a field trip translates theoretical concepts learned in a classroom into tangible expressions of geologic processes observed in the field. Few places on Earth rival Grand Canyon's ability to challenge one in applying their skills of interpretation and synthesis as they place their observations of rock outcrops and landforms into the broader context of the Canyon's geologic history. Furthermore, the sheer beauty and gravitas of the Canyon, the physical experience of being present in the environment, and the sharing of this experience through social interactions are important affective factors that support learning.[3]

Yet, few students will ever be given the opportunity to visit the Grand Canyon, or any field site, as a part of an introductory geoscience course. Cost, time, logistics, and lack of appropriate nearby field sites are obvious barriers that prevent many instructors from introducing field experiences into their courses,[4] with the latter being a specific challenge amongst urban institutions and settings. Some of these challenges may be addressed using mobile apps to increase the access to field experiences for large numbers of students.[5] Such approaches remain limited, however, for students with physical disabilities, those who face cultural or emotional barriers to participating in field experiences, or those who experience discomfort in the field.[6]

Virtual reality (VR) is therefore a particularly promising technology for overcoming barriers in introducing students to the field. Within a VR environment, students can be provided the means to navigate, observe, and interact with the environment in ways that parallel those in the real world. Educators should understand, however, that "VR" does not imply a single approach or technology. There are a wide range of opportunities for how VR might be implemented in education that have different benefits and limitations. The two experiences shown in Fig. 7.1, for example, demonstrate two distinct approaches for transporting a student to the Grand Canyon using interactive photospheres (i.e., 360° photos) versus

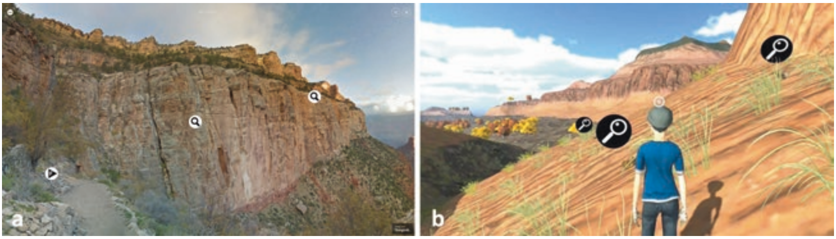

Fig. 7.1 Examples of a virtual reality field experience used to teach geoscience concepts in the Grand Canyon created using (**a**) interactive photospheres and (**b**) fully immersive three-dimensional worlds

three-dimensional virtual worlds.[7] In each of these experiences, a student can navigate through the Canyon, collect and test rock samples, and use these observations to make inferences about the geologic setting and history of the region. The degree of realism and ability to interact with the environment in each case is, however, distinctly different and neither experience provides a direct representation of the mechanics involved in real-world geologic field work.

As a result, some would argue that the VR experiences afforded by today's technology cannot replace the experience of a real-world field trip.[8] We view this issue as a matter best deferred to technology developers; perhaps technologies with a degree of fidelity to reality that rivals Star Trek's fictional holodeck will one day become available and enable the equivalence between real and virtual field experiences. In the meantime, we posit that there will always be both advantages and disadvantages in utilizing virtual versus real-world field experiences for learning (i.e., they should be viewed as complementary rather than potentially redundant experiences). It is therefore imperative to understand the affordances of real-world field trips and align them with the current VR modalities to provide guidance on how to effectively design and utilize VR technologies that provide unique learning opportunities in geoscience classrooms.

With that goal in mind, this chapter seeks to review the role of field experiences in geoscience education, outline existing modalities for VR technologies in the context of the geosciences, and suggest a simple framework for considering how the elements of presence, interactivity, and accessibility can be used to aid in the design of VR field experiences. The limited work done in geoscience-related, educational VR has been primarily centered on VR experiences created by instructors as content to be consumed by their students. We broaden our perspective to also consider student creation of VR experiences as a means of expression and assessment in geoscience classrooms.

7.1 The Role of Field Experiences in Geoscience Education

Human impacts on the Earth are increasingly apparent and have led to the recognition that all citizens require a basic level of Earth Science literacy.[9] Field learning can play an important role in this effort by linking abstract literacy concepts, such as "Humans significantly alter the Earth" (Earth Literacy Big Idea #9),[10] to tangible real-world places that demonstrate practical applications of conceptual knowledge and a cultural context that provides relevance to society.[11] Furthermore, van der Hoeven Kraft et al. highlighted the importance of connections to Earth (e.g., through place attachment, esthetics, and the formation of identity as an Earth scientist), as key affective elements to geoscience learning.[12] LaDue and Pacheo confirmed the importance of field experiences in the formation of interest in the geosciences through interviews with upper level geoscience students and professional geologists.[13] Likewise, Kean and Enochs demonstrated that geoscience field trips in urban settings are important for development of interest within non-geoscientists.[14] Specifically, these authors found that geoscience field trips built the self-efficacy and confidence of K-8 teachers from urban schools and noted that "teachers also enjoyed learning earth science concepts in the same way that attracts most professionals in the field."[15] Thus, first and foremost, we highlight the role of field experiences as a foundational step in constructing individual interest and identity in relation to the Earth Sciences for both those who might eventually become professional geoscientists as well as those from the general public.

Place-based learning has long been identified as an effective strategy for teaching important disciplinary concepts and skills situated within a specific physical environment.[16] In the geosciences, field experiences provide a real-world context for concepts learned in the classroom[17] and continue to have positive impacts on affective components of learning even for those who have already identified geosciences as a career path.[18] Kastens et al. identified learning in the field as one of four key aspects to how geoscientists think and learn, the other three being thinking across time, spatial reasoning, and understanding the Earth as a complex system.[19] In other words, these authors identify field experiences as one of the most foundational components of the geosciences. This is not surprising given that "observations play a central role in geoscientists' formulation and testing of new ideas and theories."[20]

Another of the distinctive ways in which geologists learn, spatial cognition, is developed through direct observation and interaction with geologic environments leading to an appreciation for the scale, complexity, and frequency of geologic features.[21] Experience in the field allows one to see beyond the enormous complexity of the real world and develop the ability to extract and record information that is relevant to testing mental models and hypotheses about geologic environments and processes. Kastens et al. refer to this skill as the formation of "professional vision", which is the ability to see the world through the eyes of a professional rather than a novice. Professional vision relies on the development of spatial cognitive skills, such as identifying relevant features in a complex scene (i.e., signal-noise disembedding) and visualizing three-dimensional structures from two-dimensional surfaces (i.e., visual penetrative ability).[22] An equally important skill developed through field experiences is the ability to interpret and translate observations as inscriptions (i.e., notes, diagrams, graphs, maps, etc.) reflecting an individual's understanding of the environment.[23] In other words, field experiences play an essential role in developing the skills and abilities of a geoscience student to observe, summarize, and synthesize the world around them to make order and generalizations from an otherwise seemingly complex and chaotic world.

Mogk and Goodwin identify five main areas where practitioners hold that field experiences provide value to learning in the geosciences: (1) cognitive gains, (2) metacognitive gains, (3) affective aspects of field instruction, (4) benefits of immersion in nature, and (5) foundations of geoscience expertise.[24] Cognitive benefits of field experiences are generally related to the development of higher order thinking and synthesis skills based on wholistic thinking, including the application of content learned within the classroom to a real-world environment. In contrast, metacognitive benefits are based on student reflection and self-regulation in relation to their own learning activities. For example, while working in the field, students must constantly reflect on what they currently know based on past learning experiences, whether their current observations conform to expectations, where they need to go next, and what they will do when they get there. Thus, metacognition is enabled by providing some degree of freedom for student inquiry in the field, which ultimately leads to the development of agency as an independent learner. Affective aspects of a field experience are broad and range from student attitudes and perceptions about being in the outdoors to positive (or negative) outcomes of social learning environments and mentorship. The benefits of being immersed in nature are numerous, but in the context of geoscience learning, the benefits are primarily related to understanding the complexity of earth systems and supporting affective responses related to sensory and emotional stimulation as well as being confronted with the context of real-world complexities.[25] Finally, field experiences provide an important setting for the development of professional geologists, ranging from the use of specialized tools (e.g., Brunton compass) to thinking across space and time and developing professional communication skills and ethics.

The above studies illustrate a wide range of reasons for why the geoscience community values real-world field experiences, but there has been little work done to evaluate whether VR field experiences could produce similar benefits. Drawing on the established value of real-world experiences, we suggest four major categories of benefits that could be readily translated from real-world to virtual field experiences: affective and cognitive gains, professional development, and the development of student agency through inquiry (Table 7.1). We do not suggest, however, that how these benefits are achieved in real-world versus VR experiences would be identical or that every VR experience would address these benefits in the same way. For example, the feeling of the sun on one's skin while walking down a trail in the Grand Canyon (regardless of whether pleasant or blistering) contributes to affect in a way that would be impossible to achieve within current commercial VR technologies. Yet one can still

Table 7.1 Learning benefits associated with field experiences that are readily transferable to virtual field experiences

Affect	Emotional and esthetic responses; place attachment; development of interest, enjoyment, motivation, prosocial behaviors; personal and societal relevance
Cognition	Understanding and application of theoretical concepts to real-world settings; integration and synthesis of conceptual knowledge
Professional development	Identification of patterns in complex environments; spatial cognition; specialized field skills; use of and interpretation of inscriptions (e.g., maps); collaboration, communication, and socialization
Inquiry	Construction of mental models and hypothesis testing based on field observations; open-ended investigations and multiple pathways to completion

obtain a breathtaking view of the Grand Canyon from a photosphere, which despite being one of the simplest of today's VR technologies, we have personally observed to inspire wonder and excitement in people of all ages and backgrounds.

7.2 VR Affordances That Support Virtual Field Experiences

Is the virtual view of the Grand Canyon as good as being there? Might it even be better than the real thing for those who would find hiking a trail down the Canyon to be unpleasant or would otherwise be unable or unwilling to visit the Canyon at all? The answers to these questions obviously depend on the metrics by which we define "as good as being there" or "better than the real thing" and hinge on how well a VR experience can achieve desired learning outcomes in terms of cognitive/affective gains, professional development, and inquiry. Addressing these questions requires an understanding of the affordances that current VR technologies can provide to learners through a virtual field experience. We have identified presence, interactivity, and accessibility of VR experiences as important factors that are likely to impact the success of achieving the field learning outcomes summarized in Table 7.1.

Presence is the degree to which an individual feels that they exist within or are otherwise connected to a virtual environment.[26] Presence is therefore the result of interactions between multiple sensory inputs and various cognitive processes.[27] Though there are many factors that contribute to presence,[28] in the context of virtual field experiences, we focus specifically on the concept of personal presence, which consists of realism, transportation, and sensory immersion. Realism is the degree to which a medium can produce accurate representations of environments, objects, events, and people; transportation refers to the suspension of disbelief that allows one to feel that they have been physically moved into a virtual environment; and, sensory immersion refers to engagement of multiple senses. Notably, though the terms immersion and presence are often used interchangeably in the literature, they are distinct concepts.[29] Immersion generally relates to the technical capabilities of a VR system to engage an individual's senses and thus submerge them within a virtual world and is therefore associated with the affordances of the technology, not the user's experience. For example, visual immersion is a condition afforded by the wide field of view created by a VR headset,[30] which can facilitate a user's sense of presence in the displayed environment.

Considering the role of presence is important because it relates to the potential learning benefits of virtual field experiences in multiple ways. For example, while it may seem intuitive that maximizing realism in the virtual world would support cognitive learning gains, we often use simplified representations of reality and analogies to aid students in understanding the world around them.[31] Thus, in some cases a lack of realism may be beneficial, as long as an unrealistic or inaccurate representation of the environment, user actions, or geologic processes would not lead to the formation of misconceptions or other barriers to learning. Likewise, the ability to portray varying degrees of realism in an environment could aid in developing a student's professional vision, for example, by training a student to identify features and patterns in increasingly complex environments controlled by the instructor. Being transported to the environment would aid students in understanding scale and spatial relationships, and would also play an important factor in defining affective responses to the learning activity. Thus, presence may have both direct and indirect relationships to the learning outcomes we wish to achieve in a virtual field experience and requires careful thought when designing the activity.

Interactivity provides a user some measure of control in a VR experience,[32] and is therefore directly related to the learning outcomes of a virtual field experience. Janlert and Stolterman identified a variety of aspects contributing to meaningful interactions, including intentionality and enablement in action toward a goal (i.e., agency), predictability in how one's actions will affect the environment, and the pace at which interactions are experienced.[33] We define interactivity as encompassing both a student's ability to interact with and manipulate objects in the virtual environment as well as the instructor's ability to support differentiated, scaffolded, and potentially personalized learning experiences. The degree to which a student can engage with the environment, for example, to select or manipulate an object, will define the mechanics of the activities created. Providing the ability to pick up, examine, and test objects may facilitate inquiry-based active learning exercises that motivate students to explore, ask questions, and test hypotheses more than environments where they can only passively receive information with little interaction (e.g., as in a 360° video). Notably, however, Roussou and Slater found that a guided (non-interactive) VR experience led to greater cognitive gains than an open-ended interactive experience tested with

K-12 students.[34] The ability to roam freely through an open world could empower students to change their perspective while investigating spatial relationships between rock formations or morphologic features in a way that would be impossible from a fixed spatial point of view. Virtual notebooks or other tools for documenting student understanding are important for several educational outcomes, including: the development of a student's use of inscriptions, as a scaffold for more complex learning objectives, and as a tool for assessment by instructors. The overall nature and structure of the learning experience and how a student progresses through it (e.g., through task assignments or narrative), is itself an important consideration that is central to the design of an effective virtual field experience.

Finally, we consider accessibility as an affordance of VR because students must be able to participate in a learning experience in order to receive its benefits. We mean accessibility in a broad sense of issues that can reduce participation, ranging from how easily one can acquire the required hardware to usability of the experience, lack of content interest, motion sickness, and learning or physical disabilities. It is important to consider the needs of diverse groups of learners in the development of virtual field experiences. The multi-modal approach emphasized by Universal Design for Learning (UDL) is aimed at supporting diversity in student learning needs through multiple means of representation, expression and action, and engagement—in other words the "what, how, and why" of learning.[35] VR is naturally suited to UDL as the rich environment of a virtual world can support multiple sensory inputs and pathways, for example, through visual, audio, and kinesthetic cues, and different approaches to interaction to deliver content to students. Activities can be structured within virtual worlds to engage students through scaffolding or the use of narrative, lowering barriers to forward progression through the experience. Not only is VR an approach for delivering content to students, but it can also become a pathway for student expression where they become the content creators using unique approaches in VR for demonstrating what they know. In summary, VR supports the objectives of UDL to provide educators ways to meet the needs of diverse learners[36]; to identify barriers in curricula; and to create instructional goals, methods, materials, and assessments that work for everyone.[37]

7.3 Commercially Available VR Hardware

The field of VR has been changing rapidly and there are now a wide range of approaches that can be used to produce a virtual field experience. Within the scope of this chapter, however, we consider only highly immersive virtual environments that can be experienced using a stereoscopic head-mounted display (HMD). Though used extensively for education in the past, we do not consider 3D immersive worlds like Second Life[38] or virtual field experiences created with platforms like Google Earth that are experienced through a two-dimensional computer monitor.[39] Likewise, we do not discuss recent advances in augmented reality, though there are clear opportunities for the use of this technology within geoscience education.[40]

High-end commercial hardware, such as the Oculus Rift or HTC Vive, has become synonymous with VR in recent years. These systems require a dedicated computer to run VR content and therefore provide excellent VR performance. In addition, external tracking stations can follow the headset and hand controllers to allow a user to translate movements made in real space to the virtual space. The high cost of computer equipment in addition to the HMD, however, put these computer-based systems out of reach for use in most classroom settings. In contrast, HMDs based on smartphones or standalone VR technologies may prove to be a more promising path forward in education. Of particular interest to many educators is Google Cardboard (Fig. 7.2a, b), which can leverage a student's smartphone as the device for rendering VR content with very low-cost viewers. Interactions with VR content in Cardboard are typically limited to a single button or gaze-based input. Google Daydream (Fig. 7.2c) similarly uses a smartphone to render content but adds a specialized VR controller to support a richer range of interactions. Emerging standalone platforms such as the Lenovo Mirage Solo (Fig. 7.2d) and Oculus Go (Fig. 7.2e) provide similar capabilities as smartphone-based VR, but with better performance while avoiding the cost of acquiring a high-end gaming computer. Given that new standalone systems like the Oculus Quest (Fig. 7.2f) are just beginning to provide capabilities equivalent to computer-based VR, such as room-scale movement and advanced hand controls, future standalone systems are likely to become increasingly important within educational settings. In Table 7.2 we have highlighted some of the strengths and weaknesses for common examples of each type of VR platform (i.e., smartphone, standalone, and computer driven) in terms of their affordances to support presence, interaction, and accessibility.

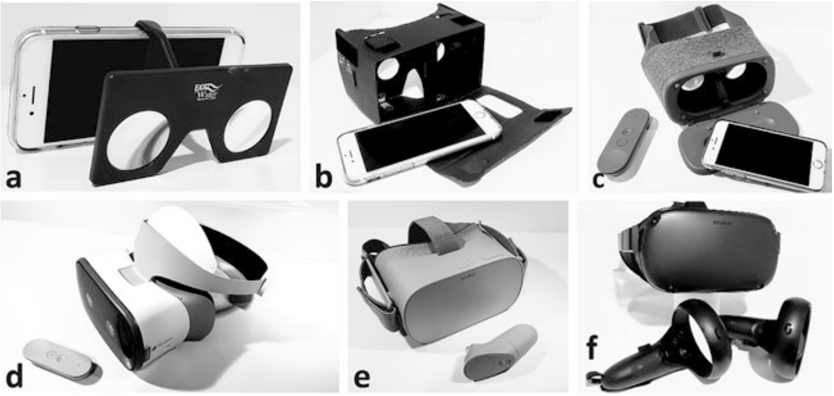

Fig. 7.2 Examples of commercially available hardware platforms for delivering virtual field experiences. Shown are examples of the Google Cardboard (**a**, **b**) and Daydream (**c**) viewers, both of which rely on smartphones, the Lenovo Mirage Solo (**d**) and Oculus Go (**e**), which are low-end standalone VR systems, and the Oculus Quest (**f**), a standalone VR system with two hand controllers that is very similar in form to computer-based VR systems (i.e., the Oculus Rift and HTC Vive, which are not shown). (Photo credit: S. Moysey)

7.4 A Spectrum of VR Software Modalities

Virtual field experiences can be implemented using a spectrum of technologies, ranging from photospheres to fully immersive and interactive virtual worlds akin to the most advanced VR video games (Fig. 7.3). One of the simplest and most accessible VR modalities is the use of 360° photospheres. These images or videos place the user in the center of an image sphere that allows for stationary viewing in all directions. For example, the easiest possible virtual field experience to implement today might involve students exploring a place using Google's Street View app, which provides a map interface to access Google's widely known collection of 360° photospheres within a Cardboard viewer. Such open-ended exploration may have some benefits, for example, students in urban areas could conduct scavenger hunts to identify intersections between geoscience and the built environment.[41] In contrast, the Google Expeditions platform was specifically designed to enable teachers to take groups of students on guided virtual field trips using photospheres, but there is no interaction capability in this system. While sharing photospheres is an easily accessible

Table 7.2 Summary of commercially available hardware platforms for VR

	Presence		Interaction			Accessibility		
	360° View of environment	Room-scale VR	Single button input	Simple VR controller	Tracked hand controls (dual)	Requires mobile device	Requires high-end computer	Cost of ownership[a]
Smartphone-based VR platforms								
Google Cardboard	✓		✓			✓		$2–50
Google Daydream view	✓			✓		✓		$100
Samsung Gear VR	✓			✓		✓		$130
Standalone VR platforms								
Lenovo Mirage Solo	✓			✓				$340
Oculus Go	✓			✓				$200–250
Oculus Quest	✓	✓			✓			$400–500
Computer-based VR platforms								
Oculus Rift S	✓	✓			✓		✓	$400
HTC Vive Pro	✓	✓			✓		✓	$1100

[a] Cost of ownership does not include the additional cost of a smartphone as it is assumed that most students will already own at least a Cardboard compatible device. An additional $1500–2500 should be included for a computer with an appropriate high-end graphics card to run the Oculus Rift S or HTC Vive Pro

entry point to VR, this type of experience is limited to "observing" the environment and does not allow for individual exploration.

Several platforms with easy to use editing interfaces (e.g., *ThingLink*, Palo Alto, CA; *Wonda VR*, Paris, France), have recently emerged to allow multimedia educational content to be embedded within an individual photosphere (or 360° video) and to link multiple photospheres together

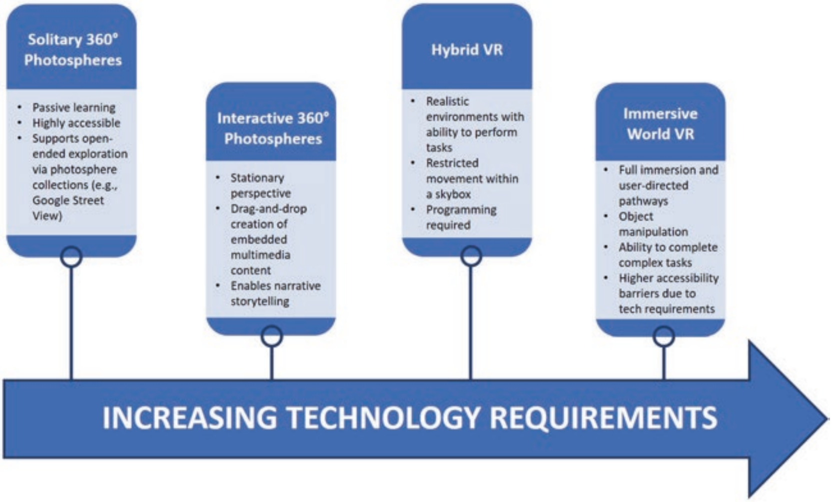

Fig. 7.3 Spectrum of VR software modalities

in a (potentially non-linear) sequence. This advance effectively transforms photospheres from a passive to active learning environment. As demonstrated in Fig. 7.4, interactions can be embedded using clickable icons within the photosphere that allow students to link to audio, images, video, websites, or a variety of other multimedia content without leaving the virtual environment. In some editors, images and video can be directly embedded as interactive elements of the environment with their behavior (e.g., visibility) defined along a timeline, similar to the capabilities of a video editor. The timeline capability can provide a variety of important and sophisticated functions within a learning experience, including the introduction of a narrative that unfolds through a sequence of events as the user progresses through the exercises.

Several types of learning objectives can be achieved using photospheres in the classroom. In a geoscience context, students can explore environments that are difficult or impossible to access due to location, scale, or risk. Such exposure to real-world field sites can help students link conceptual knowledge to real field locales. Additionally, multiple field sites can be combined to visualize deep-time concepts. The interactive photosphere in Fig. 7.4, for example, guides students through a sequence of observations

Fig. 7.4 An interactive photosphere created using the ThingLink platform demonstrates the use of embedded links within the virtual environment. In this example, students explore modern analogs to the ancient reefs that formed fossiliferous limestone deposits

of a modern coral reef environment. A second photosphere then asks students to apply these observations to the examination of an ancient reef system in the mountains of West Texas, where the embedded links allow for examination of hand sample and outcrop photos.

Place-based learning is a common thread that can be used to tie students to geoscience (and the larger world around them), yet access to traditional field sites may be especially limited in urban environments. In these instances, photospheres can be used to provide context for how familiar local resources, ranging from geologic formations to campus buildings, fit into a greater regional, national, or global context. In Fig. 7.5, for example, icons encourage students to investigate the materials used to construct a well-known campus building. Each icon leads students to a close-up view of the stone and asks them to hypothesize about the type of rock used (oolitic limestone) and the environment in which it forms. Similar to the reef example described above, students are then transported to a photosphere of a beach in the Florida Keys, where modern carbonates are forming. This place-based intervention has the potential to positively impact affect and understanding as students build connections between their familiar, local place and a far more distant location, both geographically and geologically.

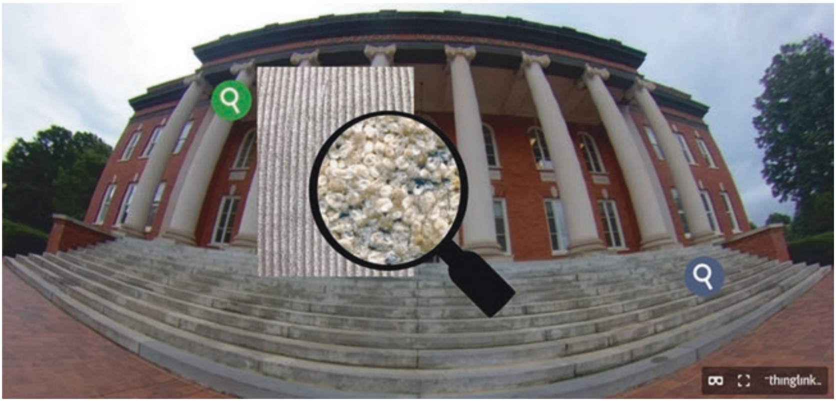

Fig. 7.5 Use of photospheres for place-based learning in familiar campus settings. In this case clicking on an icon opens a close-up image of the building façade with a magnified view showing oolitic limestone

While the above examples focus on the delivery of geoscience content to students, another means of integrating photospheres into the classroom reverses the creator role to emphasize student inquiry. Rather than exploring instructor-created content, students are tasked with telling their own geoscience stories by collecting, annotating, and disseminating 360° degree images from the field to share their knowledge and experience with their peers. Figure 7.6 demonstrates an example from a student-created photosphere tour of storm-damaged bailey bridges on the Caribbean island of Dominica. In this example, each icon displays either a picture or a video, and is accompanied by narration done by the student creator. Exploration of the photosphere introduces students to larger sustainability challenges related to frequent storm damage and asks them to consider how some of these challenges may be met. It is important to note that the position of the narrator, as a peer rather than an instructor or similar position of authority, adds an important dimension to this type of science storytelling. Digital storytelling has been shown to have positive impacts on the student creator's content mastery and learning motivation and is well aligned with the principles of UDL[42]; these impacts are likely transferrable to VR storytelling as well (though this should be investigated further). In this way, assignments which require students to create their own VR content not only serve as creative summative assessment tools, but can also be used for practicing science communication skills, developing motivation, and increasing exposure to geoscience in their peers.

Fig. 7.6 Use of photospheres to enable student storytelling of science. Here a student uses an interactive 360° degree image to explain the connections between storm flow and damage to build infrastructure in Dominica

Figure 7.7 shows a more sophisticated approach to engaging students using photospheres compared to the link-based interactions shown earlier (e.g., Figs. 7.1a, 7.4, 7.5, and 7.6). In this example, students participate in guided inquiry by performing simulated grain size analyses and acid tests for the presence of carbonate minerals to investigate the geology of the Grand Canyon. Specifically, students choose to perform these common field tests on rocks and outcrops that they encounter by selecting the rock hammer, acid bottle, hand lens, and grain size chart shown in Fig. 7.7. In contrast to the previous photosphere examples that used clickable icons for interaction, the embedded images and hotspots in the photosphere allow the tools and geologic features to become a more natural part of the environment leading to a high sense of presence. Engagement within the environment is increased through the construct of a first-person narrative; in this case, students take on the persona of a person searching for economic resources. The user moves through a sequence of photospheres that together simulate progression along a trail in the Grand Canyon, along the way determining rock properties and depositional environments to reconstruct the history of the region to guide their search. The experience requires students to apply understanding of geologic concepts

Fig. 7.7 The software Wonda VR is used here to embed images within a photosphere to enable immersive interactive content that supports inquiry, storytelling, and hypothesis testing through the exploration of the Grand Canyon

acquired from the classroom, acquire knowledge of field skills (i.e., common field tools and the importance of using outcrops in geologic studies), and construct and test hypotheses about the nature of the canyon. The realistic environment and subsequent possibility for high presence within it, paired with the interactivity and high accessibility of this type of experience could prove to be an important pathway for the dissemination of virtual field experiences in many different types of classrooms.

While the examples of interactive photospheres discussed above illustrate a promising approach for developing introductory virtual field experiences, they are limited in scope in many ways. In contrast, the use of video game engines (e.g., *Unity 3D*, San Francisco, CA; *Unreal Engine*, Cary, NC) vastly expands the potential capabilities of a VR experience. For example, a game engine allows one to construct a fully three-dimensional immersive virtual world that students can freely explore, learn from virtual tutors, and interact with the environment by taking measurements, picking up samples, or myriad other interactions limited only by imagination and programming capabilities. Game engines also allow for the simulation of real-world physics (e.g., falling rocks associated with landslides or wave motion at a beach) and complex logic that can support scaffolding, such as requiring the completion of training tasks as prerequisites to more complex activities.

Figure 7.8 shows an example of a virtual world created in a game engine that provides a parallel Grand Canyon field experience to the photosphere-based experience shown in Fig. 7.7. In the fully immersive case, students can use a Bluetooth game controller to freely roam through the landscape to make observations and collect samples. By immersing the user in the canyon and providing freedom to explore, students may be better able to understand spatial relationships in the field, appreciate scale, and form and test their own hypotheses. Rather than relying on clickable icons, this modality allows students to take their own rock samples, rotate them in three-dimensional space, work through menu prompts, and record observations in a virtual journal that can be referenced throughout the experience. This virtual journal is worth highlighting, as the ability to take 'field notes' not only reflects the practices of a field geologist and allows for the inscription of observations, but it also increases the potential for inquiry. The students can be tasked with probing more deeply into the field environment and developing more complex mental models with the virtual journal supporting (rather than overloading) the student's working memory.

Though it is a fully immersive virtual world, the experience shown in Fig. 7.8 was designed to be run on a smartphone using Google Cardboard and an external Bluetooth game controller. This hardware choice was made to enhance accessibility for a greater number of classrooms and students;

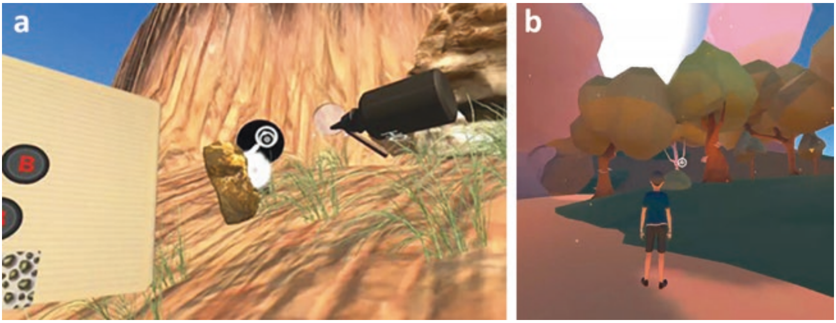

Fig. 7.8 (**a**) Animation for conducting an acid test on a rock sample in an immersive world VR experience designed for use on a smartphone with a Bluetooth game controller. (**b**) Though the user's avatar is free to explore the virtual world, the realism with which the world is represented was limited by the technical capabilities of smartphones on which the experience was deployed

however, it also introduces limitations to the experience. It was necessary to create a cartoon-like appearance for the environment due to the limited memory and computational capabilities of a smartphone. Additionally, kinesthetic interactions afforded by “picking up” or manipulating a rock or other object using advanced VR hardware cannot be achieved in this experience. The design differences between the parallel educational experiences shown in Figs. 7.7 and 7.8 highlight the need for further research to understand how the right balance between presence, interactivity, and accessibility can best support student cognition, affect, professional development, and inquiry.

The final example we present is a hybrid VR experience that aims to combine the presence afforded by the realistic imagery of photospheres with the interactivity of a fully immersive VR experience. This hybrid was developed for use on the HTC Vive and consists of a 360° photosphere of the Grand Canyon as the background (Fig. 7.9) with a much smaller ‘playable’ area for room-scale VR on a platform located in the center of the photosphere. In this experience, students can physically move around the play area to interact with three rock samples collected from the Grand Canyon. The user can pick up and manipulate any of the rocks using the HTC Vive controllers. When a rock is picked up from the platform, the corresponding rock unit is highlighted in the photosphere. Given that this experience requires a computer-based VR system, the number of students who can participate at a given time is limited by the requirements for an expensive VR headset and VR-capable computer (Table 7.2).

Beyond the hybrid experience above, the authors know of very few geology-oriented learning experiences that take advantage of advanced VR hardware. A notable exception is the virtual geology field trip developed by Klippel et al.[43] These authors have created an experience that combines photospheres, three-dimensional models, narrations, and the advanced interactions afforded by cutting-edge VR hardware to interact

Fig. 7.9 Scenes from a room-scale hybrid VR experience in the Grand Canyon

with the environment (e.g., by measuring the thickness of stratigraphic units). In student evaluations of the experience, the virtual field trip outperformed real-world field trips in a number of affective and cognitive measures. While Klippel et al. characterize the experience as "basic" within their taxonomy, we believe that this is an excellent and pragmatic illustration of what most virtual field experiences for geosciences are likely to aspire to over the next decade. Another notable example for engaging students, though not developed specifically for geoscience education, is Google Earth VR. This software allows a user to explore the globe, much like the traditional version of Google Earth but in a fully immersive environment with sophisticated hand controls that allow a user to fly through fully rendered three-dimensional terrain almost anywhere in the world. The user can also switch between the modeled terrain and StreetView photospheres, where they are available. While this environment remains limited for developing the types of inquiry-based experiences available in the non-VR version of Google Earth, combining the two versions would indeed lead to a powerful geoscience learning platform that supports both inquiry and the development of three-dimensional thinking and reasoning skills.

7.5 Conclusion

Virtual reality has the potential to support many of the fundamental learning goals practitioners desire to achieve with real-world field experiences, including cognitive understanding of geoscience content, affective experiences that contribute to interest in the geosciences, actions, and environments that support professional development, and opportunities for learning through inquiry. The degree to which any particular experience can meet these goals will depend strongly on the affordances provided by any particular VR hardware and software platform's ability to achieve presence, interactivity, and accessibility (Fig. 7.10). It is therefore important that instructors obtain a clear understanding of the current and emerging technologies that are available when designing (or selecting) a virtual field experience for use in their classroom.

As of today, any instructor can begin delivering interactive photospheres to students via their smartphones with no advanced technical or programming knowledge. This low-end VR technology is therefore an attractive path forward for broadly disseminating the use of virtual field experiences in education. The realism offered by such experiences is particularly

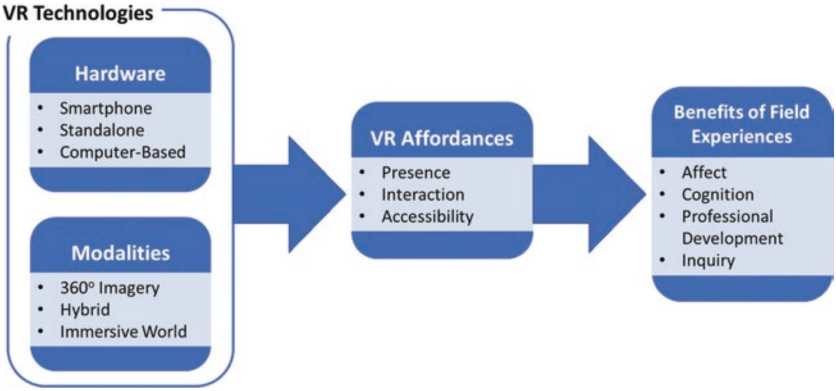

Fig. 7.10 The benefits of virtual field experiences are dependent on the affordances provided by distinctly different types of hardware and software technologies

important for creating student connections to the Earth. As shown through the examples presented here, small choices in the design of the experience, for example, whether to use icons or clickable images as content links, can have a significant impact on the sense of presence that can be achieved in the experience. In contrast, game engines have also advanced to the point where immersive virtual worlds can support complexly organized learning experiences with a high degree of interaction afforded by VR hand controls. We have only just begun to conceptualize the opportunities that high-end VR technology could provide to the geoscience classroom. The cost and technical challenges in producing this content, however, means that such experiences will likely be produced by only a small subset of the geoscience community. Furthermore, broad adoption of such experiences will require significant investments to provide the needed VR hardware. These significant barriers to adoption mean that widespread integration of high-end VR experiences into classrooms will likely follow a lengthy time horizon. Standalone VR systems may, however, be the factor that significantly shortens this adoption curve.

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CHAPTER 8

Non-fiction Virtual Reality Stories of Emigration: Points of Viewing and Creating for the Classroom

Christine Rosalia

Abstract Chris Milk, in his 2015 TedTalk on Virtual Reality, called VR "the ultimate empathy machine." The claim is that "immersive storytelling" will give participants a deeper experience. The hope is that the immersion will encourage a visceral reaction to respond, in many cases to an injustice, or at the very least, to learn more about an issue that seems distant to one's immediate life. Others argue that claims for teaching empathy are overblown and/or irresponsible. This chapter explores explicit teaching of points of view and VR creation for diverse urban classrooms where students already have life knowledge on a common VR topic: emigration. Interviews, classroom trials, and evaluations of documentary VR are used to suggest meaningful investigations and applications by teachers and students.

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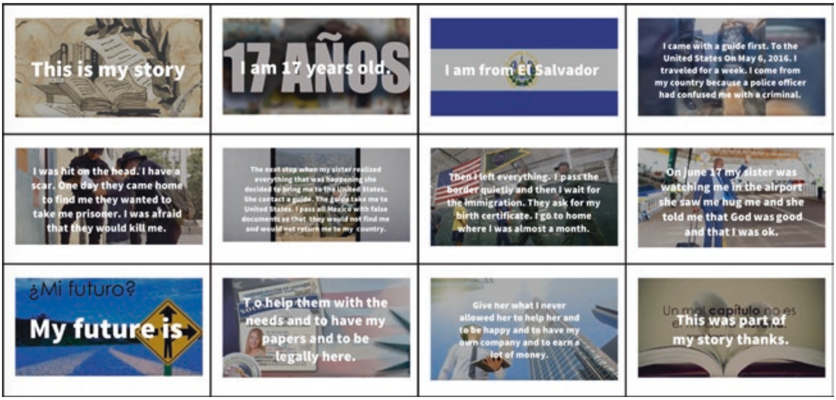
I was first exposed to the world of non-fiction virtual reality (VR) through a *TedTalk* by Chris Milk, entitled "How virtual reality can create the ultimate empathy machine."[1] In the 2015 talk, Milk introduces the medium of VR and highlights its potential through the example film he produced with Gaba Arora, *Clouds Over Sidra*,[2] about the Syrian refugee crisis narrated through the voice of a 12-year-old girl, Sidra.[3] Viewers, as he puts it, feel like they are present with Sidra:

> [Y]ou're sitting there in her room, watching her, you're not watching it through a television screen, you're not watching it through a window, you're sitting there with her. When you look down, you're sitting on the same ground that she's sitting on. And because of that, you feel her humanity in a deeper way. You empathize with her in a deeper way.

As a teacher educator, working with recent immigrants and their teachers, I was interested in exploring pedagogical uses of the VR documentary. The documentary seemed to work perfectly as a model in a course I regularly teach for English language teachers where the teachers do a ten-week case study on a student that includes the co-creation of a "digital story." Practicing teachers (or teacher candidates) use digital story as a method of assessment and teaching because of the "data" they can collect on the student as they make the story, such as information on technological literacy, first language literacy, and literacy in English. However, a not so hidden purpose of the project is to build a trusting relationship between teachers and students, as teachers better learn where their students are coming from—literally and figuratively. More often than not, especially when students are "new arrivals," the digital story tends to be a story about the student's immigration process. For instance, Fig. 8.1 shows images from a digital story made by one high school student and his teacher. Note that images with the student or family members are not shown to protect the student's privacy. In the text, you can see the student revealing his undocumented status, and even trauma related to violence from a police officer in his home country ("I was afraid that they would kill me"). His story is from the point of view of a survivor who sees his leaving El Salvador and entering the United States as only "part of his story."



This is my story

17 AÑOS

I am 17 years old.

I am from El Salvador

I came with a guide first. To the United States On May 6, 2016. I traveled for a week. I come from my country because a police officer had confused me with a criminal.

I was hit on the head. I have a scar. One day they came home to find me they wanted to take me prisoner. I was afraid that they would kill me.

The next stop when my sister realized everything that was happening she decided to bring me to the United States. She contact a guide. The guide take me to United States. I pass all Mexico with false documents so that they would not find me and would not return me to my country.

Then I left everything. I pass the border quietly and then I wait for the immigration. They ask for my birth certificate. I go to home where I was almost a month.

On june 17 my sister was watching me in the airport she saw me hug me and she told me that God was good and that I was ok.

¿Mi futuro?

My future is

To help them with the needs and to have my papers and to be legally here.

Give her what I never allowed her to help her and to be happy and to have my own company and to earn a lot of money.

Un mal capitulo no es

This was part of my story thanks.

Fig. 8.1 Sample student digital story

The co-production of such stories is a formative experience for teachers, helping them to appreciate creative personal projects like this, not as a luxury or extra, but rather as a fundamental building block to literacy and curriculum matching.[4] For instance, the student's story is narrated by him in Spanish and his teacher helped him translate it into the longest piece she had seen him write. He and his classmates were so engaged that they continued working on their stories hours after class had finished on multiple days, learning about each other and how their stories connected them. As their teacher wrote in the assignment reflection, "All stories shared similarities and differences and yet the one factor that wove them together was that 1) It wasn't an easy journey and 2) there was a real need to leave their country behind." The teacher said she witnessed "a very special new collaboration among students" due to the shared stories and the connections they made, "a goal all teachers target at some point, if not many points, in their career."

With class sizes of up to 35 students in New York City public schools, the language teachers value the insights this graduate school assignment affords. Therefore, *Clouds Over Sidra*, a personal narrative on forced migration from the perspective of a 12-year-old girl seemed, at the time, like a perfect match for language teachers and the students they teach. To complement my old digital story assignment, I introduced VR with the example of *Clouds Over Sidra* and Milk's explanation of VR. We focused on Sidra's narrative and how it told about the purpose of her migration (to escape war), what that moving felt like, and changes in her life related to moving, such as daily routines, play, family life, temporary housing, and education. As with traditional digital stories, teachers noticed how background music, narrative, and images interacted and complemented each other to “show” a story rather than “tell” or “over-direct” it. Intrigued and inspired teachers also started to use *Clouds Over Sidra* with their students as an example of good storytelling using a new technology.

8.1 GOING DEEPER AND BEYOND THE NOVELTY EFFECT

It is important to note that at this point, in 2017, many teachers and students were completely new to viewing VR even in a cardboard headset. As readers will likely know, it is not just that one needs to have a headset, but that with more accessible and cheaper cardboard headsets one is dependent on using a phone to download and play the 360-degree video. In my experience, even if a school had decent Wi-Fi and a friendly in-class cell phone policy, students often did not have enough memory on their phones to download *Clouds Over Sidra* (and the With.in app that lets them play it). Therefore, equipped with the five preloaded headsets I could provide, students would only get a quick in-class turn to see *Clouds Over Sidra* in a headset. The need to connect *Clouds Over Sidra* to curriculum and to differentiate it according to a full classroom of language learners was quickly apparent. This led to making explicit teaching materials that included views students could get of the film on YouTube using a regular computer (after or before their turn at a headset). I found different and multiple viewings not to be a disadvantage. Instead, it became useful for language learning and fluency activities. Using a YouTube transcript, I could ask students to “catch” the repetition of certain words or “spot differences” between what was written in the video transcript and what was actually said. For example, YouTube’s machine-generated transcript erroneously made the subtitle, “we worked for days,” when what Sidra actually said was: “We walked for days.”[5] Improved language comprehension and the noticing possible with repeated viewing laid the foundation for a “going deeper” activity, where students were ready to consider artistic choices the creators had made. For example, with a group of ninth graders, we considered this YouTube viewer’s response to the film: “VR is so powerful in contexts like these, it’s exciting. But why would you use a VO[voiceover] with fake, unnecessary and judgemental [*sic*] accent?”

Questions of voice and how it is both expressed and understood by audiences is a critical point familiar to literature and language teachers. Different audiences will bring different sensitivities. For instance, a ninth grader from the Dominican Republic learning and valuing the new language being learned, English, wrote “we enjoy more understanding [of] the story so I think it’s a great idea to put the voiceover in English; more people could understand it.” Another Spanish speaking student added that “more money could be made if it is easy to understand.”

However, with Arabic speaking middle schoolers from Yemen I could see an audience fighting with the voiceover, straining to hear the Arabic background conversations or to read Sidra’s lips. Wanting to use their Arabic, they were disappointed with the limited glimpses the film gave in Arabic. Likewise, a Syrian English teacher gave a negative visceral reaction: He worried about how the craft of the film played on “ignorant sensibilities.” Like Arabic speaking students, and the YouTube commenter, this teacher was more critical of the use of a young girl and how her voice and observations were being used. In other words, the film had not been made with an Arabic speaker or a Syrian audience in mind. Rather it had been made for an English-speaking audience, not familiar, or critical of the portrayal of Syrian refugees.[6]

Indeed, the named purpose of *Clouds Over Sidra* was to raise awareness and money for humanitarian aid. Chris Milk is proud of such advocacy through VR, asserting, “[w]e’re taking these films and we’re showing them at the United Nations to people that work there and people that are visiting there. And we’re showing them to people that can actually change the lives of people inside the films.” Information on how to donate to the United Nations is at the end of the film itself. *Fortune Magazine* noted the impact of viewers experiencing *Clouds Over Sidra* at a UNICEF event amounted to a donation rate of one in six viewers, twice the charity’s normal rate.[7]

The contribution of *Clouds Over Sidra*, and other subsequent VR documentaries, when measured by increased financial support to charities is an important success embedded in our current world structures and politics. However, important ethical questions should be brought up using this example,[8] and at this point in your reading of the chapter, you would benefit from watching the film, if you have not already. The rest of the chapter is framed around “points of viewing” we think should be brought to VR films. Such questions and awareness, we argue, could make the “machine” of virtual reality a more grounded and realistic tool for what we call "critical VR points of viewing and creating." Critical points of viewing and creating are important so that Milk's target audience of "people that can actually change the lives of people inside the films" does not only include audiences that consider themselves different or temporarily present. Rather it includes "people inside the films," their connected friends, families, classmates, and teachers.

8.2 Points of Viewing and Creating

A tenet of digital story making as an educational tool or method is that the process of making the story is more important than the product itself.[9] That is, the process and the learning from making the story (e.g., writing skills, understanding artistic choices, and tools) can move forward, but the product of the story becomes history. "B-roles" of production often shown at the end of a film, credits listed on film databases, interviews from participants, or director's statements are keys for teachers working with students to demystify creative choices made, and to emphasize the challenges of production. Such resources can reveal motivation for making the film, what participants personally learned, and what they want viewers to take away from their work or to discuss in post-screenings.[10]

After researching the making of *Clouds Over Sidra*, we learned that the voiceover narrative or "screenplay" in *Clouds Over Sidra* was not in fact written by Sidra, but by a producer, Gabo Arora, and team. Arora explains the tension between the purpose of evoking empathy and the staging of it: "The goal is to make you feel like you are there, and to empathize with what it is like to live there in an ordinary way. A day in the life of a 12-year-old girl in a refugee camp. But yes, it is art. Or artistic."[11] The unintended audience of the Arabic speaking middle schoolers and the Syrian teacher, mentioned earlier, in fact, had picked up on this artistic "accent" which was not authentic to their lived experiences. When they went into the virtual reality experience not intended for their point of view, they came out differently. While still impressed by the presence the 360-degree video provided, they were critically concerned about the experience and its consumption by others.

To the point that learning happens in the process of making a film and that this is what moves forward, I had the opportunity to interview a filmmaker from the *Clouds Over Sidra* production team, Ben Ross. Ben had decided after his experience working on *Clouds Over Sidra* to make a second film where he investigated the role of a director and his production team's interaction with their protagonist's voice. When asked about his approach to this second project, *Rise Above,*[12] he noted that he "went into the project incredibly cautious." He explained:

> It was just an iterative process of self-reflexivity. Of where in each moment I was checking back in with myself to see, to check my own behavior, my own language, my…um… the way that I was setting the collaboration in motion. It really set the framework for me as thinking of myself as a facilitator, rather than as a director.

Ben was conscious of "the whole idea of that role" (the director) as "very much created by men in a very patriarchal context of hierarchy, of control." He added, "I think particularly in documentaries it's not as singular … a film is [not] a single person's creative output, but more than in any other, it is a collaborative output and documentaries are even more so. And so…I think what I learned is [that] there is a responsibility as a facilitator to support your collaborators."

In addressing learning from his past work experience, for *Rise Above*, Ben said, he "initially wanted to give all of the agency, all of the storytelling process to feel like the subject of the film was at the helm of curating how it was presented, how it was framed and told." Studying Ben's process across films is important because it is a complex dynamic model that comes from making multiple films, over time (and for a career). Such critical thinking is not as easily accessed by students when they are strictly consumers. Ben explains, his processes and how he learned he could not "completely offset responsibility" for the voiceover:

> When we showed it to people it felt forced and a bit inauthentic. And I was scratching my head wondering why something I had focused so much on the authenticity of it; why did it feel inauthentic? And what I found is that ultimately my subject is still a student who is learning how to frame these things and to present them… To that extent, I have a responsibility to help and support how it is presented in a way that is the most effective, while still retaining her agency, her voice. So we went back into the studio and I took everything that she had written and I had reframed them as questions and we sat down for 2.5 to 3 hours and I asked her questions that were reframes about what she had herself written about, what she had wanted to share about her experience. And we recorded it as an interview… We were able to pull from that interview the narration of the film… [T]hat's sort of been the way I have made films ever since. It's really actively empowering other people to tell their own stories and to just sort of being a sounding board…

Understanding that teams negotiate a story and co-own the production process is an important aspect in a medium that is claiming to evoke empathy and further, participation. As Christina Ortmeier-Hooper notes in case studies of immigrant first-year students, as they negotiate their identities as second language writers in mainstream composition classes, when performances are not framed appropriately, they can evoke sympathy or a story as a commodity.[13] It would be interesting to know Sidra's reflections, especially over time, on the performance and reception of her performance. Gobo reflects:

> What I find fascinating is the power dynamic between Sidra and her audience. Usually she would have to compete for your attention. And now, because she is associated with a new tech and something cool, people are running after her! I love this. She and her story are desirable.[14]

Questions of ethical listening, facilitating, adapting, and sharing of a story show us much about the hope we have for ourselves and the world. Some teams, like Ben's *Co.Reality* production team, will ask how are we "actively embodying the consciousness we seek to create"[15] and what is a "level of collaboration that uplifts, honors, and respects the voices we represent in the stories we tell."[16] How we consume stories is important.

8.3 Classroom Investigations of the Ethics of Film Co-construction

Because VR can achieve a closeness to a subject that makes it seem as if there is no camera, we found the task of "finding the camera" and its relationship to those being filmed important for students to understand and deconstruct. When filming *Clouds Over Sidra*, Arora Gabo explains both a lack of control and a controlled persistence in staging:

> I have to leave the camera and then run out of the way and hide, and I can't see what I shot. I have no idea how it's going. I can direct people to do and act a certain way, but after a while I think they forget about the camera. Of all the scenes, I staged one. The one with the kids running at you and encircling you in slow motion? I herded about 200 kids. I was like the pied piper. We did that and made a game of running and playing for four hours.

Viewing this scene again, the curiosity with which the children look at viewer is also understood as the curiosity of children looking at an unusual camera rig. We asked our students to look for where the camera tripod had been smudged out in this scene. Additionally, our students could better see production choices when asked to examine elements of performance such as scene selection and musical editing in the film. We asked: What do you observe about Sidra? What happens in the film when you observe it? Do you hear a change in music? See a change of location? What is the filmmaker doing that may help you to notice or feel that? We believe written responses like the following demonstrate noticing of filmmaker's craft:

> The filmmaker shows us all the scenarios that Sidra [sic] could get into in the Za'atari camp. For example, her interaction with her family in their tent, in the soccer field with her friends, in her classroom with her teacher and classmates. In all these areas, Sidra feels confident, but not in the boys' area. I think in those areas, the computer room and the bakery, the atmosphere got tense, and the music in those parts of the video were different.

In future work, we would push this noticing, all the more. For example, an analysis of "author and audience" could have investigated if the filmmaker's choices reflected what could be considered a western point of view of gender relations.

To further critique a film's position and craft, we took screenshots of scenes and asked students to reorder the scenes to a sequence they found logical or useful in a retelling of the story. To push thinking of author choices even more, we asked students to compare points of view across films and to change the ending or an aspect of a documentary scene. For this, we used screenshots from the VR documentary as green-screen backdrops. In this way, we were placing our students "in" the story. Below is an image of such a retelling using a VR film, *This is Climate Change: Feast*[17] in which students changed the ending of the film. The original film ends with cows being brought to a slaughter house, but in a new student version, the student pleads with farmers not to kill the cows. We used an inexpensive mobile app called *DoInk*[18] and a green bedsheet to make green-screen recordings quick and accessible to students (see Fig. 8.2). We experimented in our film recordings with showing the camera and the classroom in which the illusion was shot. We hope these examples are useful to other educators for using the act of production to help students view and create.

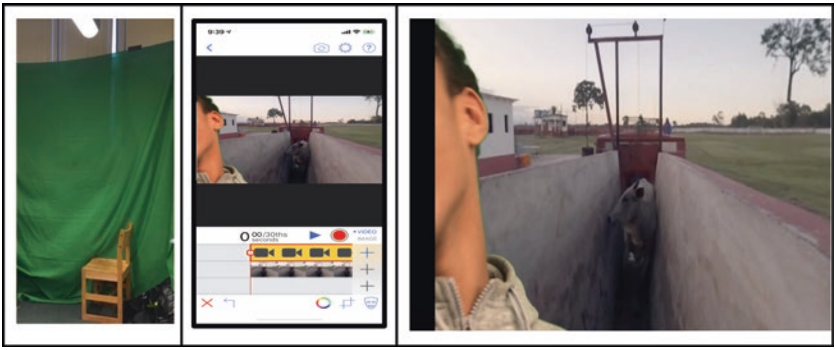


Fig. 8.2 From left to right: Classroom set-up of green screen, DoInk iPhone App production view, and final video image with student's face not in full view

8.4 Minding the Gap: Classroom Tensions as a Critical Tool

Matching *Clouds Over Sidra* to an audience of teachers and students familiar with migration taught us some noteworthy tensions and possible misuses, in fact, of VR. First and foremost, of course, when choosing VR, content matters. VR researcher Jeremy Bailenson recommends not using VR for experiencing what we *couldn't* or *wouldn't* do in the real world.[19] He gives the contrasting example using VR to fly over Pluto, but not wanting to produce a VR where the participant is able to practice a realistic virtual mass murder. We would add that VR should not be used for experiencing what one would not wish to experience again.[20] Care needs to be taken when introducing a VR, so that students do not accidently experience something which they are not ready for. In the newness of the medium teachers should note this can easily happen because access does not come with classifications or ratings like those used in movies (e.g., PG13, Excessive Violence). Showing a VR too close to a negative experience someone has had may trigger trauma. In fact, the presence VR creates is used by trained therapists, with success, as part of cognitive behavioral therapy precisely to help survivors of traumatic events who suffer from Post-traumatic Stress Disorder (PTSD).[21] We believe it is important to make sure students have a first experience with VR that is safe from emotional risks. For example, we like showing the 360 video on the making of the animated film *Isle of Dogs*. In this way, viewers orient to the presence they will feel when viewing a VR film.[22] They know the affordances of a 360 view, but this particular example does not go after a sensitive social problem.

A VR too close to one's personal experience is not the intended purpose of most VR, and although this paper argues we should pay attention when the VR experience is about "us" for its accuracy and use, VR arguably has more potential for opening conversations with students to unknown topics, or, at the least, experiences that do not trigger trauma. Teachers should be ready in any case of using VR for strong physical and emotional reactions. For example, when showing *Clouds Over Sidra* to a class of parents taking English language classes, as part of the research for this paper, I noticed tears coming out of a parent's headset. I consoled the mother who remembered her son stationed abroad with the military. As it was in this case, it is important to pay attention to responses, and be ready with post-viewing activities such as journal writing, small group discussions, and even counseling.[23]

In addition, teachers need to be on the lookout for unintended responses to VR, long term. For example, though not a classroom study, Jeremy Bailenson and Victoria Groom, experimented with using a "virtual mirror" where white participants in VR "wore black avatars" hoping that if a white person took the perspective of a black person, her racial stereotypes could be broken down.[24] However, perhaps because perspective taking was not achieved, wearing the black avatar had the unintended effect of reinforcing stereotypes and making them more salient for participants. Similar to any media content which takes on complex social issues, there is no magic bullet to changing a person's biases, explicit or implicit. This does not mean educators should not engage in such work. Rather, aligned with Michael Boatright's work investigating graphic novel representations of the immigrant experiences, we must teach students to "delve past a comprehension-level understanding of a piece of text to identify the underlying ideologies, or belief systems, inherent in any given word or image."[25] Two solutions toward building critical literacy and empathy include (1) coupling VR films[26] with more traditional print, for comparisons on a topic—this can help "readers" participate in noticing what "authors" choose to privilege intentionally or inadvertently in their craft—and (2) including discussions of what it means to be empathetic and/or to have empathy fatigue.[27]

For understanding empathy as a "motivated phenomenon in which observers are driven either to experience empathy or to avoid it" Jamil

Zaki's work is instructive.[28] Zaki positions empathy as a dynamic construct which shifts according to the characteristics of the empathizer and situations. He argues that at least three phenomena—suffering, material costs, and interference with competition—motivate people to avoid empathy, and at least three phenomena—positive affect, affiliation, and social desirability—motivate them to approach it. Using the terms of Zaki's field of psychology, for an "intervention" to work would-be empathizers must choose to carry out motives through regulatory strategies including situation selection, attentional modulation, and appraisal. In other words, as "place-based learning" VR puts us in a refugee camp to better understand a 12-year old girl's experience, but we will be motivated to take action to help her only if we see it as socially desirable to do so. We might not empathize if we find a flaw in her narrative's authenticity due to "accented voiceover" or disappointment at learning the narrative was not written by her. However, if we rate highly on a measurement of our tendency to be able to take on different perspectives, such as on an instrument psychologists use developed by Mark Davis called the "Interpersonal Reactivity Index, we might still empathize."[29] Finally, the VR film might still not inspire empathy or action for a slew of other reasons including VR causing physical sickness. While a variety of factors, including gender (women experience empathy more than men), past experience with gaming, age, and type of headset used, even conservative studies using multiple measures conclude that between 20% and 80% of VR users experience symptoms similar to classic motion sickness.[30,31]

With many social problems confronting students on a daily basis, students may need help in fighting empathy fatigue or the inertia of assuming a typical audience role. To wit, artist Ying Liu describes this usual audience-to-performance relationship as "almost like a fountain: In order to not get wet, the observer has a tendency to stay outside." In her exploration of VR, "instead of the spectator knowing exactly where and how far it [the performance] is from their seated position" she aims to have them "enveloped in it and seeking their way out."[32] In "Hang Out," her "site-specific, three-part play," Ying intentionally made the novel tools of VR (e.g., 360 cameras, cardboard viewers, camera mounts) objects audience were invited to discover and tinker with. She wanted her audience participating in and playing with the author's gaze. In our work, we also made the 360 camera and tools objects to explore.

Like Ying, we gave students opportunities to film themselves and others. When set as a producer of their own 360 film, moral dilemmas or participant discomforts became paramount. The intentional art of filming was not as easy as they had thought. For example, students had to decide where to put (and leave) the camera, and thus grapple with what Kool[33] calls the disappearance of the author and the importance of location in VR. Students were not used to emphasizing the setting of a scene, and at first, would move with the camera following a subject as they would do filming using a regular camera. With a camera that frames everything, they had to consider issues of privacy and consent in new ways. First takes showed them the importance of making sure the location was worthy of a 360-degree interest. For example, filming a direct headshot interview where a bland office setting did not add any nuances to the interview meant a 360 view was not needed. Choices made to hide the camera as in films they watched on refugees like Melissa Pracht's *We Are Rohingya*[34] were now important. As Pracht explains:

> We tried to find unique perspectives – like attaching the camera to a pile of bamboo carried between two workers – and we prioritized shots where there was a reason to look around or from one side to another so we could direct the viewer to take in the full scene.[35]

Realizations of the lack of options to pan in and out of scenes or to focus on a face as done in "flat screen" film on immigrants' first night in the United States, *HotelUSA* produced by Andrea Meller and Merisa Pearl[36] begged the question of when a 360 view was indeed, a limitation. We learned that good audio recordings and a camera timing out after every 30 minutes meant capturing scenes unobtrusively was all the more challenging. Finally, even though camera companies claimed the editing of 360 film would be easy and manageable in minutes, of course, this was not the case at all. Software apps provided with the purchase of our Insta360 camera limited editing to "trims" at the start or end of a take. For real editing, such as the smudging out of a tripod or stitching, expensive software such as Adobe Premiere was needed. This was often completely out of a student's price range, limiting learning to what might be done with a free trial.

8.5 A 360 Conclusion

Similar to the process of discovery described by Ben Ross, the way to use and make non-fiction VR ought to emphasize co-construction, and not only points of entry, but what is left behind by necessity to enter. In co-production, there are many unexpected turns and, hopefully, alliances. Such alliances are in constant flux, despite the capture of a record, even a purported 360-degree capture. This is similar to our take on immigration which tends to focus on the interruption and the entering of outsiders coming in, rather than complex stories connected to our own history. As Ying Liu reminds us, setting a proper interaction means "cultivating a mode of self-directed spectatorship."[37] Empathy is not created from watching a VR documentary, but is a critical literacy that can be better facilitated when VR documentaries are deconstructed, contextualized, located, and new ones are attempted. We have a role in the play. There is always a hand (or more precisely) hands on the machine. As Janet Murry advocates, for a community of makers and players, we should actively share "necessary mistakes, creating examples of what works and what does not work for others to build on."[38]

The concept of place is readily available to learners in VR as they can feel "present" and "immersed." So too is their access to places they would like to experience, but cannot easily experience in real life. The challenge for educators is to make students critically aware that their presence in the location is mediated by a production team and diverse points of view. In a time when we are inundated with media and screen time, a paradox has unfolded: While "screen time" has increased among adolescents and college students (among other populations) and correlates highly with decline in empathy[39] and well-being,[40] we are seeking ways through even more immersive "screen time" to increase connection among people. This paradox certainly deserves pause. So too is the commercialization of VR. Luckily, research on the impact over time and settings of the immersive experience on attitudes and behavior has begun.[41] So too, VR productions themselves are beginning to show the dangers of seeing VR as a solution to injustice or a lack of awareness. For example, the VR satire *Extravaganza* traps viewers inside an offensive puppet show where they have no control of the content or themselves.[42]

Therefore, investigating questions of production (where and how is your point of view being directed?), staging (where is the camera and how did subjects participate?), purpose (why is the film being made?) and the socio-cultural context of filming (how did the filmmakers acquire participants' consent?) is important. Questioning the audience (who is the film being made for?), authorship (who is the author or authors of any of the narratives being told?), language (how and what languages are prioritized?) and, finally, distribution (where will the film go and for how long?)

is a process of critical literacy we hope to impart to others working with "vulnerable" and "privileged" populations: that is, all viewers. VR, like any medium, has the power to dispel or create points of view that are not in aid of a better world. We need to question why and how presence, perspective taking, collaboration, trust, and connection develop in a continuous human way before and after VR as an "empathy machine," is placed, willingly, over our eyes.

NOTES

1. Chris Milk, "How Virtual Reality Can Create the Ultimate Empathy Machine," filmed 2015 at TED2015 in Vancouver, Canada, TED video, 10:25, https://www.ted.com/talks/chris_milk_how_virtual_reality_can_create_the_ultimate_empathy_machine#t-54386
2. Gabo Arora and Chris Milk, "Clouds Over Sidra," filmed March 2015 at the Za'atari Refugee Camp, Jordan. 360 Video, 08:35, http://with.in/watch/clouds-over-sidra/
3. At the time, news outlets like the *New York Times* were also featuring stories about Syria that had interactive 360 elements such as this one on a town in Germany that had been grappling with immigration. See especially Chapter II: When do four walls become a home? by Kassie Bracken, https://www.nytimes.com/interactive/2017/04/28/world/europe/syrian-refugees-weimar-germany-women.html?_r=0&smid=pl-share
4. Work using digital story creation with teachers and students is described in Christine Rosalia, "Preparing Preservice Teachers' Expectations and Resilience: Service Learning with English Language Learners" in *The Handbook of Research on Community Engagement in 21st Century Education*, ed. Cate Crosby (Hershey, PA: Idea Group Inc., 2016), 24–47.
5. Other language learning activities included students changing spoken language to written language using proper sentence boundaries marked by capitalization and punctuation. A sample material made can be found at https://drive.google.com/open?id=1nQI2IbzCjcM3KtHI56AMyEE3uaDLdIj9RkK9swMeHGY
6. Another example of a stark contrast in how viewers might see or portray 360 views of locations in crises is the instance of when Facebook's Mark Zuckerberg in 2017 livestreamed a VR tour of Puerto Rico in the wake of Hurricane Maria. While critics saw it as a clear example of offensive "disaster tourism," he saw it as a way of demonstrating that "One of the most powerful features of VR is empathy." Saying his goal was "to show how VR can raise awareness and help us see what's happening in different parts of the world." See: Carolina Moreno, "Mark Zuckerberg Responds to

Backlash over Puerto Rico Virtual Reality Video," *HuffPost, Latino Voices*. October 10, 2017, https://www.huffpost.com/entry/mark-zuckerberg-responds-to-backlash-over-puerto-rico-virtual-reality-video_n_59dd0b27e4b0b26332e72396. Alternatives for looking at disasters such as the Haiti Earthquake include this interactive simulation that asks audiences to consider points of view of a survivor, aide worker and journalist: http://insidedisaster.com/haiti/experience

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8. Hollis Kool, "The Ethics of Immersive Journalism: A Rhetorical Analysis of News Storytelling with Virtual Reality Technology." *Intersect: The Stanford Journal of Science, Technology, and Society* 9, no. 3 (June 2016): 11 http://ojs.stanford.edu/ojs/index.php/intersect/article/view/871
9. Joe Lambert, *Digital storytelling: Capturing lives, creating community*. (New York: Routledge, 2013). 224.
10. An example "Filmmaker questionnaire" useful in teaching about process, can be found at SIMA classroom: https://simaclassroom.com. After you watch any film, the same Filmmaker Questionnaire appears. A noteworthy one from the filmmaker of the VR film *Refugee*, is available here: https://simaclassroom.com/refugees-filmresources#1492558557065-18372191-132f
11. Kel O'Neill, "The UN's First Virtual Reality Documentary Puts You Inside a Syrian Refugee Camp," *Vice, The Creators Project*. February 3, 2015, accessed June 10, 2019, https://www.vice.com/en_au/article/jpv5ng/virtual-reality-doc-puts-you-inside-a-syrian-refugee-camp
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16. Ross, "Rise Above," 360 Video, commentary text.
17. Danfung Dennis and Eric Strauss, *This is Climate Change: Feast* (With.in, 2019) 360 Video, 09:12, https://www.with.in/watch/this-is-climate-change-feast
18. See DoInk app at http://www.doink.com
19. Jeremy Bailenson, *Experience on Demand: What Virtual Reality Is, How it Works, and What It Can Do*. (New York: W.W. Norton & Company, 2018): 250.

20. My collaborators, Emma and Brittany, and I are always looking for interesting VR that students might be familiar with in order to raise critical points of viewing. One of our search strategies was to search for VR by the locations or countries we knew our students were from or to use videos set in the United States. An example of a VR we would not show to students or teachers because of topic and location is one on a first-grader's trauma after a school mass shooting. See: The Washington Post, *12 Seconds of Gunfire: The True Story of a School Shooting*, YouTube 360 video, published April 28, 2019. 07:38, https://www.youtube.com/watch?v=L6ZlUP4o6Yc
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22. FoxSearchlight 360°, *Isle of Dogs: Behind The Scenes* (FoxNextVR Studio, 2018), 360 Video, 05:21, Published March 15, 2018 https://www.youtube.com/watch?v=JqXC46b1uUg
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26. For VR on forced migration we have found for instance, the VR films, Eduardo Hernandez and Yori van Gerven, *Refugees* (Justin Karten, 2016) 360 Video, 07:00. https://www.youtube.com/watch?v=LFIuhy7Ypf0&feature=youtu.be and Imraan Ismail and Ben C. Solomon, *The Displaced* (The New York Times, 2015), 11:08, https://www.with.in/watch/the-displaced
27. A great starter for defining empathy is Brene Brown's work. See this animated introduction: https://www.youtube.com/watch?v=1Evwgu369Jw
28. Jamil Zaki, "Empathy: A Motivated Account," *Psychological Bulletin* 140, no. 6 (2014): 39.
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31. Gregor Geršak and Huimin Lu. "Effect of VR Technology Matureness on VR Sickness." *Multimedia Tools and Applications* (2018): 17.
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33. Kool, "The Ethics of Immersive Journalism."
34. Melissa Pracht, *We Are Rohingya* (Stina Hamlin and East Coast Digital, 2018) 360 Video, 09:00, https://www.doctorswithoutborders.org/what-we-do/news-stories/story/video-we-are-rohingya
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CHAPTER 9

Computational Thinking and the Role-Playing Classroom: A Case for Game-Based Learning in an Interdisciplinary Context

Reneta D. Lansiquot, Tamrah D. Cunningham, and Candido Cabo

Abstract Although game-based learning is becoming prevalent in higher education to promote student motivation and active learning, educators have not reached the potential of this pedagogical strategy. Due to games being so accessible, teachers can use digital and non-digital games not only to teach single disciplines but also in interdisciplinary settings. This chapter describes our use of game-based learning, specifically design-based games, in interdisciplinary contexts in several courses. We argue that this high-impact educational practice is an effective way to help students develop computational thinking and problem-solving skills. We also show how teachers can use design-based games to help students develop their writing skills by helping them to formulate a thesis, identify supporting evidence, and present and argue their points.

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Keywords Computational thinking • Design-based games • Game-based learning • Interdisciplinary • Narrative design • Virtual place-based learning

In an earlier chapter, we explored the concept of interdisciplinary virtual place-based learning.[1] We will now connect virtual place-based learning to game-based learning, the latter of which allows learners to role-play and to explore virtual environments. Game-based learning is a pedagogical strategy that incorporates digital or non-digital games into a course curriculum to enhance learning. Scholars define it as creating an environment in which game content and gameplay enhance knowledge and skill acquisition.[2] As games become more pervasive in higher education due to their appeal, educators are more often using game-based learning as a pedagogical strategy. Studies have shown how effective game-based learning can be in higher education and the results of implementing games within a curriculum.[3] It was common to see that by implementing game-based learning, there was an overall increase in students' motivation, engagement, and skill transference.[4] However, this type of learning method tends to get confused with gamification.

Gamification is incorporating game elements into a course without using an actual game. Using this strategy, educators may setup the course in the form of quests, give students objectives that they need to meet in order to reach their goals, and enable them to acquire rewards. They may also invoke a level of competition between the students to increase motivation in the class. The overall purpose of gamifying a class is to invoke active learning. However, gamification does not tap into the true potential of games, which is what game-based learning does. Not only does game-based learning promote active learning, but it also allows students to physically interact with a game, analyze it, and try to understand how the game helps them learn a topic. In addition, in using design-based games, students can create and test games that they designed from start to finish, become more motivated to experiment to see what works, notice what does not, and research new skills and knowledge in order to make their ideas more realized.[5]

In this chapter, we describe several implementations of game-based learning in interdisciplinary contexts in several courses. We show how game-based learning is an effective pedagogical strategy that helps students develop computational thinking and problem-solving skills. We also show how game-based learning can be used to help students develop their writing skills by helping them to formulate a thesis, identify supporting evidence, and present and argue their points.

9.1 Interdisciplinary Design Game-Based Learning as a High-Impact Educational Practice

To be competitive in the local and global economies, college graduates need to develop a number of critical skills, including communication skills (read, write, multimedia), collaboration and teamwork, creativity and imagination, critical thinking, and problem-solving.[6] Other important skills are leadership, intercultural awareness, information and technological literacy, and citizenship and civic literacy. To help students develop and acquire those critical skills, educators rely on curriculum development and pedagogical delivery. There are significant challenges in curriculum design, implementation, and pedagogy to make possible that every student graduates with the critical skills needed in the workplace. Inadequate curriculum design and implementation, failure to use novel pedagogies, and the lack of learning transfer between courses may lead to student attrition and low graduation rates. Our approach to curriculum design and pedagogy using interdisciplinary design-game-based learning addresses those challenges. The effectiveness of game-based learning in different learning environments has been reviewed elsewhere.[7]

9.1.1 Writing and Problem-Solving Are Skills Difficult to Teach and Learn

At our institution, first-year college students majoring in computer systems typically take two courses that are critical to their success in college and beyond: English Composition (EG1) and Problem-Solving with Computer Programming (PS). Students face considerable challenges to succeed in those courses: the pass rate (C or better) for EG1 is 69% and the pass rate for PS is 76% (institutional data). We believe that academic challenges during their first year are, in part, responsible for the low one-year student retention rates in our programs: 60.1% in the associate degree and 78.5% in the bachelor degree.[8] Although the challenges faced by first-year students in gateway courses are likely multifactorial, we found that teaching writing and computer problem-solving courses in an interdisciplinary game-based learning environment improves retention and student success.

9.1.2 Computational Thinking Should Be a Critical Skill for All Students

Computational thinking is the application of computing concepts and skills to solve problems, not only in computer science but also in other disciplines. Computational thinking can help students frame problems in a variety of fields and disciplines (not just in the STEM disciplines) in novel ways, and in so doing, they become better problem solvers in their majors and future professions. Some important mental processes of computational thinking include (a) decomposition, which involves breaking down problems into manageable parts, (b) pattern recognition, which is identifying trends and patterns in data, (c) abstraction, which is identifying and extracting the relevant information from a problem and being able to relate it to other problems, and (d) algorithm design, which involves creating a sequence of steps to solve a problem.[9] We believe that computational thinking should be part of a twenty-first century liberal education for all students, including those not majoring in computer science. Computational thinking should not be confused with digital, computer, or technology literacy. Computational thinking is about the mental processes to solve problems; computer literacy is about the practical skills to implement a solution that a computer can understand and/or execute (i.e., writing or executing a computer program).

Many students not majoring in computer systems at our institution take the first-year PS course to satisfy the computer literacy requirement in their major or to learn computational thinking concepts. PS is a challenging course for computer systems majors and even more so for non-computer majors. In assessments of computer programming concepts and skills, 44% of computer systems majors taking the PS course demonstrated an adequate understanding of computer programming concepts and could write viable programs.[10] In contrast, only 30% of non-computer majors taking the PS course perform adequately in computer programming concepts and skills.[11] Those assessments indicate that teaching computational thinking concepts and skills to non-computer majors require pedagogical strategies that are different from those that may work with computer science majors.

9.1.3 Learning Transfer Between Courses Does Not Occur Automatically

Students need to complete a combination of courses in their major and general education courses to graduate. Each degree program has well-defined learning outcomes that are mapped to the learning outcomes of each individual course within the program. Students are expected to establish connections and transfer knowledge and skills between the different courses of the curriculum. More often than not, however, students do not understand why they need to take general education courses, or how those general education courses contribute to their success in the major and beyond, upon graduation.

The transfer of concepts and skills between courses is a challenge. Students tend to perceive courses in their major and general education courses as unrelated to each other, and, consequently, they do not transfer skills between those courses. The knowledge transfer problem occurs not only between general education and courses in the major, but even between different courses in the major. The lack of transfer between courses is likely due to multiple factors. Students may have forgotten some of the material learned in a previous or related course; students may not perceive the connections between courses; students may see the connections but are unable to use the material in meaningful ways in a different context; or the pedagogical approach used by instructors may not be conducive to transfer.

Different approaches have been used to facilitate transfer of learning: the use of reflective writings, contextualization of learning experiences, and application of learning to real life. Multiple strategies have been suggested to encourage transfer: making the need for transfer of learning explicit to students, advising students to take courses in the appropriate sequence, emphasizing in each course the material that students need to transfer to other courses, “practicing” transfer by inviting guest lecturers, developing metacognitive skills, and reinforcing concepts by using them often and in different contexts. Regardless of the strategies used, it seems apparent that transfer of learning does not occur automatically and that curriculum and course design should intentionally emphasize the connection between courses to stimulate transfer.

9.1.4 Using Design Game-Based Learning in Problem-Solving Courses

We found that game-based learning in an interdisciplinary environment improves student creative writing and computer problem-solving skills, as well as interdisciplinary competence. This curriculum design and pedagogical approach addresses the three challenges outlined above: poor student performance in seminal writing and problem-solving courses, feasibility to expand computational thinking to students not majoring in computer systems, and facilitation of knowledge transfer between courses.

The main goal of the PS course is to introduce computer systems and engineering students to problem-solving strategies and to prepare them for a subsequent programming fundamentals course using a full-fledged programming language like C++ or Java (CS1). Before spring 2010, the PS course was taught using a full-fledged programming language (i.e., Visual Basic), and most problems and projects proposed to students had a strong mathematical or accountancy component. This curricular approach resulted in high attrition (course withdrawals) and low passing rates. We identified two major challenges faced by students in the PS course: (a) Students were not well prepared in mathematics and this lack of understanding of the problem domain translated in an inability to develop computer problem-solving skills; (b) Even when students were able to develop a strategy to solve a problem, the complexities of the syntax of full-fledged programming languages can be overwhelming to students and create additional obstacles to implement a solution and develop computer problem-solving skills.

We first introduced elements of design game-based learning in the PS course curriculum in spring 2010 using a 3D environment to create interactive animations. Learning computational concepts and skills using *Alice*[12] directly addressed the two major challenges faced by our students. Instead of working on mathematical problems, students had the opportunity to develop computational thinking concepts and skills by designing and implementing their own computer games, a problem domain with which our students understand and are comfortable. Writing computer programs with *Alice* is easier than writing programs with a full-fledged programming language. To write a program using *Alice*, students add blocks containing specific programming instructions instead of having to type those programming instructions from scratch, therefore reducing considerably the complexities of the syntax of programming languages.

The introduction of *Alice* in the curriculum of the PS course reduced significantly the rate of students who withdrew from the course from 20% to 16%.[13] The intervention also increased significantly the passing rate in the course by about 8% (from 70% to 78%) in comparison to the Visual Basic-based PS course.[14] We conducted this study in a large sample of students over a period of two years before and two years after the curricular change in spring 2010[15] using best practices to assess curricular changes.[16] We used a control group, specifically students who used Visual Basic in the PS course, and an experimental group, those students who used *Alice* in the PS course, and we assessed the similarity between the control and the experimental group by a problem-solving questionnaire at the beginning of the semester.[17] We further stratified the results by instructor to account for differences in instructor teaching styles and assessment patterns.[18]

Several learning theories help explain the success of the incorporation of game-based learning in the curriculum[19] including constructivism[20] and flow.[21] Constructivism posits that learning is an active process where learners create new knowledge from their previous knowledge based on their perception of reality. With game-based learning, students develop their understanding of computer programming concepts and their skills as they create and develop games with *Alice*, connecting that understanding with what they already know about games. The process of learning is psychologically demanding. There are several psychological states that can occur during learning, including anxiety, apathy, arousal, boredom, control, worry, and flow depending on the balance between challenge level and the skill level.[22] Flow is an optimal psychological state that a person experiences when engaged in an activity that is both challenging and has the appropriate level of difficulty for the person. It is possible that the use of game design as the domain to learn computer concepts and skills in the PS course promotes an equilibrium between challenges and skills needed to learn computer problem-solving concepts, nudging the students' psychological state to the optimal flow state.

One important goal of the PS course is to prepare students for a subsequent programming fundamentals course, where students learn fundamental concepts of procedural and object-oriented programming using a full-fledged programming language. Students taking the *Alice*-based PS course passed a subsequent course in Java programming at a better (although not statistically significantly different) rate than students who took the more traditional (Visual Basic-based) PS course.[23]

Overall, these results suggest that introducing design game-based learning in problem-solving courses improves student performance and retention. It also shows that the use of design game-based problems and assignments in the PS course does not hinder student performance in subsequent programming courses using a full-fledged programming language like Java, which is critical for students pursuing a career in computer systems.

9.1.5 Design Game-Based Learning in an Interdisciplinary Context Further Improves Outcomes

When we implemented game-based learning in an interdisciplinary context, student retention and performance in the PS course further improved. We created an interdisciplinary learning community linking EG1 and the PS course for first-year computer systems students. A learning community is a group of students taking together two or more courses, linked by a common theme, in a given semester.[24] Learning communities is one of the high-impact educational practices shown to improve retention and student performance in different educational environments.[25]

In the learning community, students cooperatively write narratives in the EG1 course (i.e., create their own stories that serve as a background for a game) that they later implement as a video game prototype in the PS course using the *Alice* computer programming environment. When students take the *Alice*-based PS course as part of a learning community, student retention and student performance are better than when students take the *Alice*-based PS course outside the learning community.[26] There are two elements that could explain the success of adding an interdisciplinary learning component to game-based learning: the narrative and creative context for problem solving.

As part of the interdisciplinary learning community students learn about narratives and how to create stories in the EG1 course (the narrative context is not prominent when the PS course is taught outside a learning community). Stories and narratives are important cognitive tools to learn about and to understand the world.[27] Atif Waraich nicely expressed this idea that narratives provide learning motivation and meaning when discussing the use of game-based learning to teach binary arithmetic: “For any learning task to be meaningful to the learner they [the learner] must have both a sufficient context for the learning and motivation to perform the tasks that will help them to learn. We believe that game-based learning environments that incorporate a strong narrative can meet these requirements if the learning tasks are appropriately designed and tightly coupled with the narrative."[28] Similarly, based on our experience, an interdisciplinary learning community with strong narrative components linking writing stories with writing code improves students' ability to transfer programming concepts to practical programming skills.[29]

We believe that interdisciplinary competence should be an integral part of undergraduate education. Interdisciplinary courses help students make connections between courses in general education and their majors and among courses in their majors. We applied the lessons we learned about design game-based teaching and learning in an interdisciplinary context to the development of a liberal arts general education interdisciplinary course, entitled *Programming Narratives*, combining creative writing and computational thinking. The course is aimed at non-computer systems majors with the goal of providing a majority of students at our institution with a course to develop creative writing and computational thinking skills as well as interdisciplinary awareness.[30] Similar to what computer systems students do in the interdisciplinary learning community, in the interdisciplinary course, students develop original stories, which they later implement as a video game prototype using computer programming. This interdisciplinary approach is effective in teaching creative writing and computational thinking concepts and skills to non-computer majors and helps students make interdisciplinary connections.[31]

Using the interdisciplinary design game-based learning pedagogy described here, students (a) become better writers and communicators; (b) improve their general and computer problem-solving skills; (c) develop interdisciplinary awareness; (d) develop an ability to transfer knowledge and skills across disciplines; and (e) develop collaboration skills. These learning outcomes are consistent with the learning outcomes of nationally recognized high-impact educational practices.[32] It should prove beneficial to test the curricular and pedagogical approach described here (i.e., 'interdisciplinary design' game-based learning) in different educational institutions and environments to further support our assertion that game-based learning should be considered a high-impact educational practice.[33]

9.2 Exploring Language and Technology: A Collaborative Case Study

We created and team taught a general education interdisciplinary course that provides an introductory exploration of the relationship between language and technology by reviewing the history of various technologies of the word, including writing, printing, and digital media. The course also explores the history of rhetoric and its relationship to traditional, print-based technologies, as well as new forms and meanings of digital literacy. While students in this language and technology course, who were perusing varied majors, prepared for their group term paper, there was an example for each step the students had to complete.

Before the students were grouped up to write their term paper in this new course, they had to first develop their individual thesis. In order to do this, each student had to create their own concept map based on his or her thesis and preliminary research. Once the groups were decided, group members worked together to develop an outline to further develop the idea established from the concept map. Finally, the group completed a final version of the concept map before writing their term paper. As the students went through this process, we created a model of a sample paper to provide a guideline for how they could approach the creation of their thesis. The model paper focused on narrative games because game-based learning has been proven to enhance active learning. With its inherent interdisciplinarity, the inclusion of narrative-focused games within the course can accomplish two goals: (a) promote active learning while (b) also teaching students the process of developing a thesis, identifying supporting evidence, creating concept maps, and presenting and arguing their points.

The model sample term paper concept map and outline, integrated language and technology by examining the cyclical progression of storytelling in digital games in relation to the advancement of artificial intelligence (AI) in digital game development. The model explores the difference between procedural narratives, which are stories developed by the game developers and typically have a linear story progression, and emergent narrative, which are stories that the players create using the game's world and the agency the developers assign players.[34] The thesis of this paper is that as AI advances in digital game design, the way stories are told shifts from procedural narrative to emergent narrative; the way players tell stories becomes like tabletop role-playing games, in which players create and expand upon narratives. We designed a third of the class so students would have a chance to see the steps of formulating the sample thesis. They were assigned readings that helped define narratives in games, the current methods of digital storytelling being implemented, and how the evolving technology helps shape how developers tell stories. To supplement these readings, students played games in class that supported the argument presented in the paper. As a result, students were able to use similar steps to create and support their own thesis.

We designed the model term paper in two parts: a concept map and an outline. *Visual Understanding Environment*, a free software program was used to create the concept map.[35] This allowed us to visually map the model term paper to show how the essay would use the various readings and game examples as supporting evidence for the thesis. It also had the added benefit of visually showing the cyclical progression of storytelling in digital games, specifically how it starts from the players developing their own stories by using pen and paper, similar to tabletop role-playing games like *Dungeons & Dragons*, and loops back to players creating their own stories by using the robust AI technology and randomness that allows for players to have more agency in how the narrative of the game progresses, such as the *Shadows of Mordor's* Nemesis System, which implements a revenge and grudge system that has enemies remember the player and hunts them down. This allows players to create intricate and unique stories about rivals they created and bested. We developed the outline based on the concept map and offered a more detailed breakdown of the thesis, noted points to develop for each section of the paper, and included all the necessary references.

Group papers explored issues from morality in video games to how Instagram has taken away our voices and identity. For the former, students argued that the development of game mechanics, game design choices, and game narratives focuses on establishing their own type of moral code that has players questioning every decision that they make in a game. Students posited that modern games have more of an impact on a player's cognitive development. They supported their argument by discussing readings used in the model paper alongside their own related references and discussed modern games whose narratives gave players many moral choices with major consequences to the plot of the game. Their concept map resembled that of the model term paper though the cyclical design used depicted the order of their supporting arguments.

In the latter, instead of games, students focused on social media. They argued that the social media platform Instagram is designed and marketed in a way that the users end up losing their ability to communicate with people in real life and be true to their own identity by creating a persona or imitating popular people. Students in this group were also able to use the model concept map and outline as a guide to clearly breakdown their argument and supporting evidences.

9.2.1 Interdisciplinary Writing

Moving forward, we plan to develop an effective method to grade interdisciplinary writing.[36] Although the Mansilla, Duraisingh, Wolfe, and Haynes[37] rubric is not meant for grading, it does provide educators with a sense of the interdisciplinarity of student writing. They divided their rubric into four categories: purposefulness, disciplinary grounding, integration, and critical awareness. The following are the four categories and the questions asked for each.

Category 1, *Purposefulness*, involves the following questions: (1.1) Does the student's framing of the problem invite an integrative approach? (1.2) Does the student use the writing genre effectively to communicate with his or her intended audience? Category 2, *Disciplinary Grounding,* involves the following questions: (2.1) Does the student use disciplinary knowledge accurately and effectively (e.g., concepts, theories, perspectives, findings, examples)? (2.2) Does the student use disciplinary methods accurately and effectively (e.g., experimental, design, philosophical argumentation, textual analysis)?

Category 3, *Integration, involves the following questions:* (3.1) Does the student include selected disciplinary perspectives or insights from two or more disciplinary traditions (presented in the course or from elsewhere) that are relevant to the purpose of the paper? (3.2) Is there an integrative device or strategy (e.g., a model, metaphor, analogy)? (3.3) Is there a sense of balance in the overall composition of the piece with regard to how the student brings disciplinary perspectives or insights together to advance the purpose of the piece? (3.4) Do the conclusions drawn by the student indicate that understanding has been advanced by the integration of disciplinary views? Category 4, *Critical Awareness,* involves the following questions: (4.1) Does the student show awareness of the limitations and benefits of the contributing disciplines or how the disciplines intertwine? (4.2) Does the student exhibit self-reflection?

Based on the questions provided by the aforementioned rubric, we chose five questions that best suited our interdisciplinary writing context. From Category 2, we used Question 2.1. From Category 3, we used Questions 3.1, 3.3, and 3.4. Finally, from Category 4, we used Question 4.1. We then created a revised version that could be used to grade interdisciplinary writing. We developed ten criteria: five from the aforementioned rubric and five from the rubric traditionally used to assess and grade student writing. The other half of our grading rubric focuses on the structure and mechanics of the writing, as well as how well students were able to properly cite and use the mandatory sources for their paper.

9.3 Future Directions

We plan to incorporate non-digital game-based learning alongside digital game-based learning to make our courses more accessible. With non-digital games, students have a chance to interact physically with the pieces and can see all the mechanics come into play without having to learn a programming language or become proficient in an advanced technology. However, digital games are likely more recognizable and familiar to students. As such, offering both will provide students a chance to experience different dimensions of the games. In order to do so, students will collaborate to design a narrative-focused tabletop game (e.g., board games, card games, and abstract games, specifically, 'virtual' role-playing games that focus more on strategy and rely less on random chance). A model tabletop game would be developed so that students would have a chance to play it and get a sense of how they can approach an assignment.

This model game, tentatively titled *Delve Deeper*, would be a short roll and move board game that studies video game addiction and the effect of a game's narrative to create such an immersive experience that players lose touch with reality. As players progress through the board, they will continually have to roll a dice that dictates how addicted they are to the game itself. The increase in addiction points increases the difficulty to perform the regular actions on the board that represents reality. The purpose of the game is to argue that the stronger a game's narrative is, the higher the chance that a player would be more immersed into the game, which then promotes gaming addiction. This game also has relevance to current events with the discussion of classifying video game addiction, also known as gaming disorder, as a behavioral addiction by the World Health Organization. Once students play this game, they should be able to create their own tabletop game ideas that will not only be based on course topics, but will be able to act as a possible thesis for their term paper. Ultimately, the model game would provide substantial preparation to approach the final assignment.

9.4 CONCLUSION

The use of virtual environments to create games has a real positive effect on student learning outcomes. Educators should consider ways to contextualize abstract concepts using design-based games. In an interdisciplinary context, especially when drawing connections between seemingly exclusive domains, game-based learning can be implemented on different levels. From having students create their own games, to learning the fundamentals of computer programming and general problem-solving, to having games be used as a model and an outline to develop a thesis and term papers, the application of games is only limited to the creativity of the educator. The future of game-based learning is in narrative design. Having students create as a way to understand fully the subject is the highest form of learning that can be achieved.[38] This high-impact practice will allow educators to help students reach that goal.

NOTES

1. See Tamrah D. Cunningham and Reneta D. Lansiquot, "Modeling Interdisciplinary Place-Based Learning in Virtual Worlds: Lessons Learned and Suggestions for the Future," in *Interdisciplinary Place-Based Learning in Urban Education: Exploring Virtual Worlds*, ed. Reneta D. Lansiquot and Sean P. MacDonald (New York: Palgrave, 2018), 133–145.
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4. Rula Al-Azawi, Fatma Al-Faliti, and Mazin Al-Blushi, "Educational Gamification vs. Game Based Learning: Comparative Study," *International Journal of Innovation, Management and Technology* 7, no. 4 (2016): 132–136.
5. See Reneta Lansiquot, Tamrah Cunningham, and Candido Cabo, "Game-based Learning in an Interdisciplinary Context: Making the Case for a High-impact Educational Practice," in *Proceedings of EdMedia + Innovate Learning*, ed. J. Theo Bastiaens (Amsterdam, The Netherlands: AACE, 2019), 1138–1141; David R. Krathwohl, "A Revision of Bloom's Taxonomy: An Overview," *Theory into Practice* 41, no. 4 (2002).

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8. Institutional data; students enrolled in fall 2016.
9. Google-Computational Thinking for Education, "CT Overview." Accessed June 10, 2019. https://edu.google.com/resources/programs/exploring-computational-thinking/#!ct-overview
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11. Lansiquot and Cabo, "Making Connections."
12. See Alice, software, accessed June 10, 2019, http://www.alice.org
13. Candido Cabo and Reneta D. Lansiquot, "Synergies between Writing Stories and Writing Programs in Problem-Solving Courses," in *Proceedings of the 2014 IEEE Frontiers in Education (FIE) Conference* (New York: IEEE, 2014), 888–896.
14. Cabo and Lansiquot, "Synergies between Writing Stories and Writing Programs in Problem-Solving Courses."
15. Involved 683 students using *Visual Basic* and 765 students using *Alice*.
16. Anissa All, et al., "Assessing the Effectiveness of Digital Game-Based Learning."
17. Anissa All, et al., "Assessing the Effectiveness of Digital Game-Based Learning."
18. Cabo and Lansiquot, "Synergies between Writing Stories and Writing Programs in Problem-Solving Courses."
19. Qian and Clark, "Game-based Learning and 21st Century Skills: A Review of Recent Research."
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25. George D. Kuh, *High-impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter* (Washington, DC: Association of American Colleges & Universities, 2008).
26. See Cabo and Lansiquot, "Synergies between Writing Stories and Writing Programs in Problem-Solving Courses;" Reneta D. Lansiquot, Ashwin Satyanarayana, and Candido Cabo, "Using Interdisciplinary Game-based Learning to Develop Problem Solving and Writing Skills," in *Proceedings of the 121st ASEE Annual Conference* (Washington, DC: ASEE, 2014).
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28. Atif Waraich, "Using narrative as a motivating device to teach binary arithmetic and logic Gates," in *Proceedings of the 9th annual SIGCSE conference on Innovation and Technology in Computer Science Education,* 97–101. New York: ACM, 2004; cf. Mary Jo Dondlinger, "Educational Video Game Design: A Review of the Literature," *Journal of Applied Educational Technology* 4, no. 1 (2007): 21–31.
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30. Candido Cabo and Reneta D. Lansiquot, "Integrating Creative Writing and Computational Thinking to Develop Interdisciplinary Connections," in *Proceedings of the 2016 ASEE Annual Conference & Exposition* (New Orleans: ASEE, 2016).
31. Cabo and Lansiquot, "Integrating Creative Writing and Computational Thinking to Develop Interdisciplinary Connections."
32. George D. Kuh, *High-impact Educational Practices.*
33. Cf. George D. Kuh and Ken O'Donnell, *Ensuring Quality & Taking High-Impact Practices to Scale* (Washington, DC: AAC&U, 2013); Lansiquot, Cunningham, and Cabo, "Game-based Learning in an Interdisciplinary Context: Making the Case for a High-impact Educational Practice."
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37. Mansilla et al., "Targeted Assessment Rubric."
38. See Krathwohl, "A Revision of Bloom's Taxonomy."

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