Virtual Site Visits: Student Perception and Preferences Towards Technology Enabled Experiential Learning

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Richard leBrasseur (✉)
Dalhousie University, Nova Scotia, Canada
r.lebrasseur@dal.ca

Abstract—Site visits are a key pedagogical tool within natural science and geographical education. Site visits provide an interactive experience to enable learning through the exposure to a real-world spatio-temporal environment. COVID-19 restrictions required the development of a virtual site visit for a landscape ecology course in North America. In this study, a series of digital tools were coordinated to deliver site visit information focusing on multi-sensory, multi-scalar, and multi-media information based on Kolb's experiential learning model, particularly Step 1, the concrete experience. This research explored student's perceptions and opinions of the digital tools provided to complete their ecological restoration management assignment and their effectiveness and usability. 4th year natural resource and environmental science students (n=52) reported predominately positive attitudes towards the use of the virtual site visit. Though students did not prefer the virtual site visit over a physical site visit, they noted that the virtual site visit digital tools did provide the same information as a site visit and that they felt they were able to understand all aspects of the physical site through the virtual site visit tools provided, particularly through the digital photographs and the 360-degree virtual reality imagery. Successful student assignments illustrated experiential learning outcomes were met.

Keywords—virtual site visit, experiential learning, student preferences, technology enhanced learning, pedagogical approach

1 Introduction

1.1 Site visits

A site visit (SV) is an interactive experience important within many natural science and civil engineering curriculum [1, 2] where students are physically transferred to a real-world outdoor environment. The learning objectives of a site visit require the student to comprehend the state of the site or landscape [3] and integrate the knowledge delivered within the classroom [4]. In the context of this paper, landscape is the term used to indicate the intersection of geography and ecology within the natural sciences. Natural sciences, thus, often reflect the concept of landscape and its physical, spatial, and cultural characteristics [5] and, specific to earth sciences, considers it as a dynamic system with spatial structure formed by natural and cultural elements [6].

Site visits have traditionally been an integral component of educational curriculum in many earth science domains. Site visits provide opportunities for students to have experience with the dynamic and complex environment, to explore, document, and analyze specific components of the landscape, and to communicate with fellow students and instructors in-situ the current state of the landscape. Challenges exist when implementing physical site visits as a teaching method. In addition to the social-gathering limits imposed through transmissible disease, there are safety, access, weather, and site hazards which may impose limitations to a site visit. The instructor has no control over environmental distractions such as inclement weather and noise. Sites may not be located within reasonable distances to universities [7]. Site visit expenses are often passed on to students, thus impacting student resource equity. Additionally, students with little or no prior experience in the field may have difficulty making detailed observations and taking meaningful notes about the site, thus missing the main learning concepts [8, 9]. These are among the many issues creating barriers to site visit learning experiences and their curriculum incorporation.

A virtual site visit (VSV) provides students the ability to not physically be present at a location or place while being able to explore and learn from an internet-connected device. VSVs are present in many natural science and geography curricula and supported by rapidly developing technology to deliver the important skills and achieve the student learning objectives [10, 11, 12, 4]. However, it is unclear which specific tools and delivery methods are best suited to student learning and whether a 'virtual' site visit can replicate the experiential, in-depth learning of a 'real' site visit.

This study illustrates a VSV approach which facilitates learning though the constructivist pedagogical elements of experiential learning [14] specific to site visit learning. It is hypothesized that by actively engaging students in a multi-scalar, multi-media, and multi-sensory VSV, student levels of satisfaction and perception of the VSV as an effective learning tool are similar to those of a SV. The aim of this study thus is to collect and examine student opinions and experiences with digital technological tools used to enable a virtual site visit for a landscape ecology course.

This paper is structured as follows. First, a brief overview of learning frameworks including technology and their applications to site visits is followed by a literature review of virtual site visits as a pedagogical tool. David Kolb's experiential learning model is outlined and applied to the VSV. The methods for this study's VSV delivery are presented followed by the questionnaire format as the means to analyze student opinions. The results are tabulated followed by their discussion. Reflection on pedagogical implications and future areas of study are included in the conclusion.

1.2 Site visits and student learning frameworks

Common learning objectives for site visits include the visualization of theoretical concepts, the understanding of site dynamics, and the awareness of contextual relationships [15]. The spatio-temporal component of a site visit is directly associated with the environmental information [16] such as site location, landscape conditions, trends of change with respect to ecosystems. This provides students with real-time, first-hand exposure to observe, collect, record, perceive, evaluate, interpret, reflect and communicate the complexities and characteristics of the site [17]. This learning through the experience of being in the physical site is key to knowledge acquisition and reinforces class-based learning [8, 18, 19].

The concept of active-learning [20] requires student engagement within experiences often separate from traditional lecture teaching formats and include fieldwork, site visits, community engagement, and other pedagogical approaches where students are the primary actors [21, 20]. Site visits include active learning, which incorporates a range of constructivist and experiential elements that engage students in the learning process. Constructivism [22] is the primary framework for contemporary learning [23]. Kolb's Experiential Learning Theory (ELT) [13] places experience as the key element in learning and acquiring knowledge [24]. Students are able to actively or passively process their experiences to increase knowledge through that experience itself [25]. Experiential learning is epistemologically structured through John Dewey's notion of continuity of experience and interaction [26].

Experience based learning is a cyclical learning model with 4 stages required by student to engage in: concrete learning, reflective observation, abstract conceptualization, and active experimentation [27, 28]. See Figure 1. A fifth stage, reflective personal observation, occurs when the learner reflects on the cycle as a personal growth experience. This cycle allows re-application through the steps with the new knowledge generated.

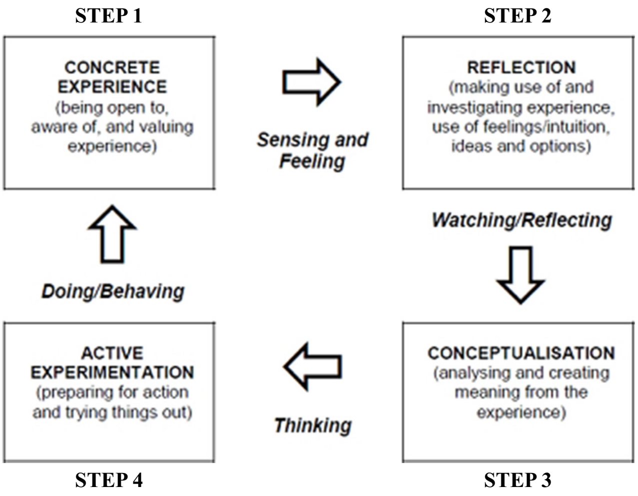

Fig. 1. Kolb's 4 stage experiential learning model

In the natural sciences, and specific to site visits, the learning cycle is iterative and often begins with the actual experience of a physical site visit and interaction (Step 1), thereby allowing observation and reflection to occur (Step 2). Site visit information is synthesized into abstract concepts of site interactions (e.g. site processes, impacts, change, etc.) and meaning (Step 3). This then leads to potential actions (e.g. restoration, management, etc.) and ideation (Step 4). Lastly, the new information and experiences renews the learning cycle [29].

Of course there are many more learning styles than those presented but Kolb's foundational concepts allow for important aspects within the process of learning. Learning flexibility and adaption is an important concept to both the delivery and method of information dissemination and uptake [30]. Learning is also impacted by interpersonal beliefs and cultural background [31]. Furthermore, the cross-cultural capacity for construction and co-construction of knowledge is increased [32] within the learning cycle.

Scientific research has shown that contextual awareness of any problem plays an important role in the learning process [33]. However, learning is not simply about doing the action outdoors. On a site visit, information and sources of knowledge are more often related to seeing, hearing, and experiencing than to reading [34]. Learning through visiting sites provides students with spatio-temporal awareness through unique opportunities for observing a real context [35]. Field-based learning assists students in better understanding core concepts [36] and raises learning avidity [37, 38]. A site visit's learning experience involves a direct, explicit encounter with the landscape, often within complex and dynamic physical contexts, but there is an assumption that such a direct experience is required to produce positive knowledge acquisition and meaningful learning [39].

1.3 Site visits and technology

A significant amount of research has been conducted surrounding technology and learning. Studies have shown the use of Information and Communication Technology (ICT) or digital tools within classrooms increase the development and delivery of knowledge for university students [40, 41, 42]. ICT tools include digital or electronic devices such as computers, tablets, drones, virtual reality tools, the internet, video conferencing, software, and other audio-visual multimedia. Current students are often technologically competent in digital consumption and digital learning skills [44]. Students less-proficient in English language skills noted improved learning within technology-based courses taught in English, including language pronunciation and comprehension [45]. Students appreciate digital technology's ambient learning (i.e. flexibility and differing learning approaches) to meet their needs [46, 47, 48].

Digital-based site visits as a learning opportunity bases much of its pedagogy on principles of technology-enhanced learning (TEL) [49]. TEL incorporates ICTs in innovative and transformative means, particularly for the natural science and environmental study disciplines where TEL can impact the learning experience through new social and cultural learning contexts and the convergence of practical and theoretical perspectives [50]. TEL tools have previously been shown to be useful in higher education to help natural science and environmental studies students achieve levels of academic success such as higher grades [51, 52]. TEL has its challenges. Group collaboration, social contexts, and team dynamism can be difficult [53]. Research is unclear if digital tools can provide similar experiential learning outcomes such as sustaining student engagement and [54].

1.4 The virtual site visit

The site visit is a multi-sensory environment which enables learning through observation, reflection, exploration, participation, and engagement [15]. The use of digital tools and technology is a rapidly expanding component of gathering site specific information remotely [43] as well as delivery of curriculum. A virtual site visit (VSV) provides students the ability to not physically be present at a location or place while being able to explore and learn from an internet-connected device. Particularly with the COVID-19 pandemic preventing many students from leaving their homes or attending group classes, the need for an effective, interactive virtual site visit becomes critical to meeting learning objectives within geology, landscape ecology, civil engineering, and other natural sciences. The VSV framework offers instructors a new tool for working with students where engagement with the landscape is a critical learning outcome.

Stainfield et al. [4] adeptly summarized the benefits of a VSV. First, curriculum modification, like most other virtual classes, is more flexible and can occur at any time. Secondly, the type of data is more diverse than traditional site visits – varied information such as websites, videos, imagery and other types of digital data is easily added and modified. Class sizes are not limited to physical constraints such as transportation capacity, opening hours, and social-gathering limits. Furthermore, a VSV is less reliant on in-person visitation requirements which could be adversely affected by weather, accessibility, and site hazards. Lastly, a VSV is less impactful to sensitive areas required for observation and analysis and increases overall student safety. For example, sites once deemed 'off-limits' for various reasons may now be considered. Other benefits of a VSV include reducing emissions and transportation costs and minimizing student out-of-pocket expenses. Disabled or impaired students are not limited to physical site visit requirements. VSVs provide student and instructor flexibility and diverse learning approaches to meet their individual needs [48]. Other VSV benefits include time efficiency, reduced paperwork, and reduced supervision issues [55]. Importantly, students are able to complete their assignments more effectively at their own pace and in their own experiential contexts [54].

However, VSVs require substantial preparation and production and the hardware and software required may be cost prohibitive. Additionally, VSVs can be digital device memory consumptive and wi-fi signal dependent. Another new learning platform required by students and staff is also a shortcoming. Futhermore, the lack of physical exposure to the site and landscape processes may result in a lack of real-world problem solving and in-depth analysis of site-specific contextual issues. For example, Jacobsen et al. [13] reported that although VSV's provided limited observational opportunities, they do allow for longer and more in-depth field sample enquiry. Repeated physical site visits present multiple environmental conditions. Nevertheless, benefits are notable, allowing for increased access within a safe and controlled (i.e. virtual) environment.

The concept of site-based learning opportunities through digital environments is not new [4, 12]. Experiential learning is a core principle within digitally delivered curriculum and teaching [56], sometimes referred to as electronic experiential learning (EEL) or digital experiential learning (DEL). Many TEL tools exist for interactive learning within site visit contexts. They include photographs, sound recordings, videos, virtual environments, augmented reality, and 3-D modeling among others in a rapidly expanding technology sector. Available tools which provide information to various aspects of a VSV include PanoraMap thru Google Images, VRGIS, LandSerf, and others. Beyond static data, interactive media such as virtual reality (VR) headsets, immersive virtual environments, augmented reality, and synchronized audio-video mapping facilitates a unique learning opportunity. Additionally, 360-degree VR images create an immersive experience when viewed from a computer screen (i.e. no headset required) similar to the continuum of Google street-view images. Since 2016, immersive virtual reality (iVR), now referred to just as VR, entered the mainstream though headsets though the primary application was for virtual tours such as in museums, natural parks, and real estate.

Web-based VSVs have been widely used within geology education. For example, researchers at Arizona State University designed and developed VSVs with embedded diagrams, hi-res images, and URLs to with 360° imagery of sites [12]. Geology instructors at Duke University in 1992 created 18 computerized field trips by integrating satellite images and topographic maps with 3D rock samples and placed on CD-ROMs for student use [57]. Shi et al. reported in a comparative study of VR and in-situ site visits that the VR was reliable in creating similar cognitive responses [87]. In a recent United States study, a virtual reality platform was used to conduct an overseas site visit, thus reducing the associated costs and environmental impacts typically associated with a physical visit, providing a less environmentally harmful approach to allow student learning while minimizing carbon emissions [59]. The UN's Sustainability Development Goals and universities world-wide continue to advocate for environmental sustainability and it is anticipated that VSVs will increase in the future.

The use of VSVs has increased mostly due to technological innovations [10], and studies have reported positive learning outcomes within geoscience courses [12, 58]. Jacobson, Militello and Baveye [43] reported the development of a series of VSVs to sites worldwide in order to present students with complicated real-world situations and to apply critical analysis skills. In another study, students in an introductory geosciences course were divided into two groups with one attending a physical site visit and second group utilizing a VSV and VR. The virtual students reported increased enjoyment, learning experience and actual lab grades [11]. Alternatively, Makransky et al. [60] reported that the use of VR may not be positively correlated with learners' performance, likely the result of the extra cognitive load required by the VR system. Similarly, lack of 'realism' [61, 62] and that a VSV will not produce a meaningful emotional connection [63] has been a common critique of virtual site visits.

Beyond simply looking at static photos, digital technologies offer the ability to view the site more holistically and thoroughly. Virtual site visits which use diverse technologies allow for a more in-depth understanding of site dynamics, providing a means to see the varied scales of landscape forms and processes and the interrelationships among landscape elements. A VSV should also create an emotional engagement to the student, similar to a physical site visit [64]. This requires data found within various spatially-explicit levels of geographies [65] and their different landscape typologies [66] and multi-dimensional information (e.g. biophysical, socio-cultural, eco-spatial) [67, 68], reflecting a student's interaction with the physical site.

1.5 The virtual site visit and the experiential learning model

The VSV accommodates diverse learning styles or modes of learning and can have direct pedagogical benefits [69]. Specifically, all four stages of the Experiential Learning Model [27] still occur. See Figure 2. In Step 1, 'concrete experience' in the truest sense of an in-situ site visit is replaced by the VSV, but the VSV is still a learning experience and perception, even digitally, activates this step of the learning cycle. Here, the student receives a stimulus through TEL tools which acts as the concrete experience – the VSV and its varied digital media and tools – for which information is processed and thus begin the Experiential Learning Model (ELM).

In Step 2, the student reflects upon that VSV experience by formulating an observation or processing the information and analysing the landscape's qualities to reach Step 3 where a conclusion or summary about the landscape can be made. This step's abstract conceptualization synthesizes and contextualizes the VSV experience within each student's unique information assimilation process. Lastly, Step 4 expands reflection-based thought to engage in exploration and action such as developing management strategies or ecosystem restoration approaches. Overall, the Experiential Learning Model and its 4 Steps illustrate the transformation of experience into applied knowledge.

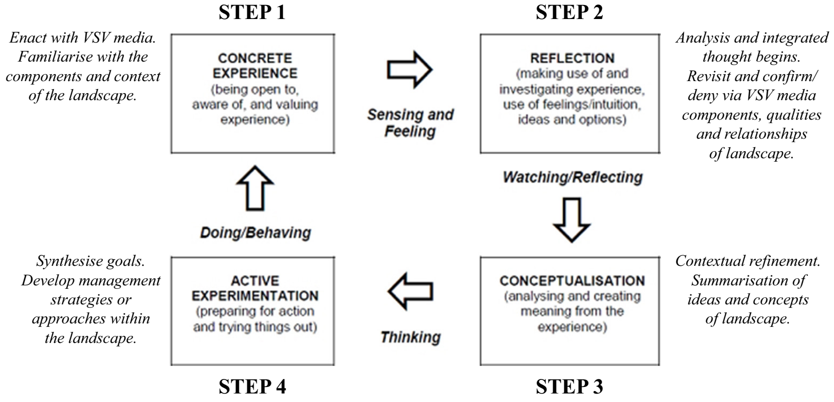

Fig. 2. Kolb's 4 stage experiential learning model within the virtual site visit

Experience, as per ELM, occurs primarily within Step1, apprehension, and Step 2, comprehension, though all four stages combine to facilitate an integrated, constructivist learning outcome [29]. Apprehension-comprehension involves the perception of experience, while intension-extension, found within the last two Steps, involves the transformation of the experience. One without the other is not an effective means for acquiring knowledge [29]. Synergistic learning transactions between the person and the landscape still occur with the VSV in the ELM cycle where students are able to co-develop their own situated knowledges about the site [70, 25]. Students are able experience tangible learning experiences, both observational and participatory [54] within the VSV [71, 72]. Repeating this Model's cycle, or creating new 'concrete experiences' at Step 1, develops new knowledge and pathways to critical and interdisciplinary thought, for example, in engineering problem solving or resource management.

Site visits, ELM's Step 1, the concrete experience, or an interaction with the world, provides a learner with a reference point through physical stimuli, textures, feelings, meanings, and emotional impulses [26] in which to complete the remaining steps and is the foundation for this paper's VSV framework and study. Additionally, the VSV allows Step 2's reflection and comprehension to occur without the need for a physical site visit. The student can conduct analysis and integrated thought, important components of ELM's Step 2 and Step 3, by revisiting the site through the VSV data at any time, creating a new 'concrete experience' in which to facilitate learning [29]. Furthermore, in-situ environmental distractions or safety concerns are alleviated with the VSV, thereby promoting reflective observation and conceptual meaning development critical to this pedagogical framework.

Many tools or vehicles exist to facilitate experiential learning within site visit contexts. New technologies have enabled virtual experiential learning to succeed in the limitations of in-situ site visits primarily though ICTs which actively engage and stimulate the senses [63, 73]. Virtual site visits have been shown to be an effective interactive learning tool [54]. The experiential qualities of a VSV allow students to re-visit the data with new conceptual learning thus increasing observational skills and focus of assignment requirements [74]. VSVs can be an alternative or complement to field activities [75] and allow for more efficient time spent on-site allowing for a more focused analysis [4].

However, questions remain as to what are the best procedures and technological tools to engage students in virtual site visit learning within the earth sciences. Whether a 'virtual' site visit can replicate the experiential, in-depth learning of a 'real' site visit is not well understood; nor is their effectiveness and usefulness towards student's learning across disciplines. For instance, civil engineering and construction courses have used VSVs to assess construction management [76] and teaching construction technology [77]. In the geosciences, virtual field trips using VR technologies have shown to increase student engagement [78] and understanding [79]. Furthermore, studies have not adequately assessed student perceptions, opinions, or behaviors of VSV tools [63].

The purpose of this research is to analyze natural science student's behaviors, perceptions and opinions in the use of various digital tools applied within a VSV in an undergraduate landscape ecology course assignment. This research seeks to better understand its efficacy, usability and generate constructive knowledge in the use of digital technologies within VSVs, including potential obstructions to the initial steps of experiential learning, methods of pedagogical development and delivery, and site comprehension in the site visit context.

2 Methodology

The objective of this study is to explore through descriptive research student responses and reactions to the use of a virtual site visit in an undergraduate landscape ecology course. Students included those from the natural science disciplines including geology, landscape ecology, natural resources, landscape architecture, plant science, and environmental science. Students were traditional 4th year within a Canadian University-based institution. In this study, the VSV was required to complete the class where an actual site visit could not be completed per COVID-19 restrictions and safety concerns. Students had completed physical site visits in prior courses and had lectures to prepare them for the assignment and context.

For this study, the site analysis assignment required students to individually inventory and document the many landscape elements of the site including biophysical, geographical, and cultural aspects through a site analysis map and a written report. The site used was a large forest and field tract next to a 40-acre decommissioned military base and airfield in Nova Scotia, Canada. The assignment required the completion of a landscape management plan or ecological restoration program. This assessed student learning outcomes of abiotic and biotic component identification and documentation, cultural and natural influences within ecological pattern assessment and interaction, landscape process and disturbances, and mediation recommendations which meet appropriate ecological goals and objectives.

The VSV for this assignment was constructed and delivered by synthesizing literature surrounding Kolb's ELM with available digital tools and technology focusing on Step 1 of the ELT model – 'Concrete Experience'. The aim was that the VSV should replicate to the best degree possible an actual, physical visit to the site thereby encompassing multi-dimensional exploratory and educational learning opportunities.

2.1 Multi-scalar, multi-media, and multi-sensory site documentation

The comprehensive documentation of the site included purposeful organization through three distinct yet interrelated approaches to capturing experiential site information and characteristics to present a 'concrete experience': multi-scalar, multi-media, and multi-sensory. Multi-scalar data includes site imagery and data of different scales: macro- and micro-scale such as satellite orthophotos, forest tracts, and site-specific photos of surface soil texture, insects, and leaf buds. Multi-media data incorporates different delivery mechanisms such as photographs, video, audio, VR capture, sketches, reports and maps, physical samples, and notes collected during multiple site visits by the instructor. Multi-sensory refers to the five human senses: sight, sound, smell, taste, and touch.

The first objective was to document the numerous landscape features, elements and characteristics through multi-scalar and multi-media data collection. This required a physical site visit by the instructor. Multiple videos and audio recordings were created. 360-degree VR images were captured with a GoPro Fusion camera mounted on a tripod. Real-time VR movement was not captured such as for use with WondaVR or Unity 3-D – only multiple static 360-degree images. Sketches, drawings, and field sample imagery were provided. The instructor also gathered comprehensive data from various sources including remote-sensed information such as ortho photographs, google earth, google street view, and others such as reports and maps. Overall, the data collected included a diverse set of static and interactive media within each approach.

The second objective was to deliver this VSV information in an effective format to meet student learning objectives which support the ELM. The virtual site visit's data and media was delivered through an interactive web-based application, Prezi (www.prezi.com), considered most intuitive to navigate and coordinate course content, but many web-based applications exist (e.g. Camtasia, Powtoon, Canva) and all function as a cloud-based repository for digital data and information. This interface allowed for the singular depository and delivery of a comprehensive online learning tool. See Figure A1 – Appendix) and included an interactive, geo-referenced map to access the VSV information. See Figure A2 – Appendix.

The following paragraphs describe the data collection and virtual coordination process in detail and is accompanied by a series of Figures. These Figures are representative of only one area, Area #6, an intermittent wetland and grassland, as an example of the interactive media and multi-sensory data collected and delivered. See Figure A3 – Appendix. or the visual data was straightforward and included a plethora of imagery including static photographs, videos and VR scenes as discussed prior. See Figures A4 and A5 – Appendix.

The instructor purposefully documented diverse locations as well as temporal differences (e.g. morning, afternoon, evening) where possible. Sound or the auditory data was captured also focusing on diversity (e.g. edge of road, middle of wetland) and temporality. See Figure A6 – Appendix. Geo-referencing and text notes were provided to clarify sound signatures. Smell or odorant data was a unique site element, research is not clear on effective strategies for describing the characteristics of smell without scent-enabling digital media or odor generators [80, 81]. The instructor documented descriptive words and adjectives within a word cloud format noting the descriptors from a variety of sources such as research articles, Wikipedia pages, google search responses, instructor notes, and others. For example, the smell of a small wetland within the site produced diverse odor descriptors such as organic, peaty, stinky, wet, fresh, mucky, sour and others. No scale or level of odor strength was provided for each descriptor unless this odor was distinctly noticeable (e.g. sulphur within a coastal tidal marsh). Additionally, pollutants and other unique odor emissions were noted and geo-referenced such as air drift from industry. Taste data was likewise difficult to capture and a similar descriptive methodology to smell was utilized. Touch or tactile data required a similar approach to documentation as smell and taste.

The author was responsible for determining the locations and those site characteristics to include in the documentation, purposefully choosing a diversity of overall landscape locations and unique or noteworthy environments. See Figure A3 – Appendix. For example, not every forest tract was documented in a thorough manner, as their characteristics were similar throughout the site; but where disease or forestry management practices were noticeable, or the edge conditions were unique, these were documented. For the wetland areas, three diverse wetland types were chosen and multiple scaled images and varied perspectives (e.g. ground level, eye level, long perspective, short perspective, overhead) and images of physical samples (e.g. soil, plants, insects) were provided. To be clear, the purpose of the VSV in this study was not to visualize data or to graphically represent information; rather, it was to utilize technology to comprehensively capture and deliver the physical qualities and characteristics of an actual site visit to the best degree possible to assist students in their assignment. This was completed by the author, considered an expert in the discipline.

The course was taught in two separate semesters with two unique sets of students, n=25 and n=27, respectively, for a total number of 52 respondents, 22 female, 30 male. Students worked alone to develop a 24″ x 36″ digital site analysis map and a 1500-word report. Traditional scientific data collection and field verification was not part of this study's assignment.

The questionnaire was provided to students once the site analysis assignment was completed and grades received. The questionnaire had an introductory page outlining the goals of the VSV within the class and the approach to provide the VSV data for the assignment. The survey generated quantitative and qualitative data and was operationalized through *SurveyMonkey* with 8 questions for which 7 were discrete multiple-choice Likert-scale gradients and one required a qualitative written response. The questionnaire did not analyze the effectiveness of the VSV in terms of learning outcomes or student grade success but was focused on assessing experiential learning constructs of efficacy, usability, and practicality based upon experiential learning principles. Specifically, how well did the VSV serve as a foundation or deliver the 'concrete experience' of ELM's Step 1 and the student's perception in applying the VSV knowledge within ELMs remaining steps.

Questions 1–4 assessed student's agreement with statements and a 5-scale Likert response of *1-Strongly Disagree, 2-Disagree, 3-Neither Disagree nor Agree, 4-Agree, 5-Strongly Agree*. Questions 5–6 asked for them to identify their most and least helpful VSV tool. Question 7 asked for their overall satisfaction level with the VSV and Question 8 was a write-in for any comments. The questionnaire was anonymous and did not ask for any demographic information such as gender, nationality, or age and had no time limit.

Table 1. Student questionnaire

Question #	Question
1	Please rate your level of agreement to the following statement: I was able to understand all aspects of the physical site through the use of the VSV tools.
2	Please rate your level of agreement to the following statement: Completing the site analysis and report assignment through the VSV and without a physical site visit enabled me to complete the assignment to a high level.
3	Please rate your level of agreement to the following statement: I prefer to engage in a virtual site visit (e.g. video, VR, pictures, audio, movies, etc.) rather than a physical site visit.
4	Please rate your level of agreement to the following statement: The VSV, as a whole, including the diverse tools, information and media, provided the same sort of information as visiting a real site.
5	Select the VSV tool which <u>most</u> helped you understand the site without being physically there.
6	Select the VSV tool which <u>least</u> helped you understand the site without being physically there.
7	Overall, rate your satisfaction level to the use of the VSV within this course to provide you with the tools and knowledge to succeed in the site analysis and report assignment.
8	If there any other comments you would like to add about the Virtual Site Visit website and information used in this course, please write them here. This survey is completely anonymous and we will never know who submitted answers. Thank you for your feedback.

3 Results

All students completed their assignment with acceptable grades – there were not fail marks given. There was a total of 52 questionnaire responses (n=52, 100% response rate). Figures 3–6 and Table 2 present results of each question.

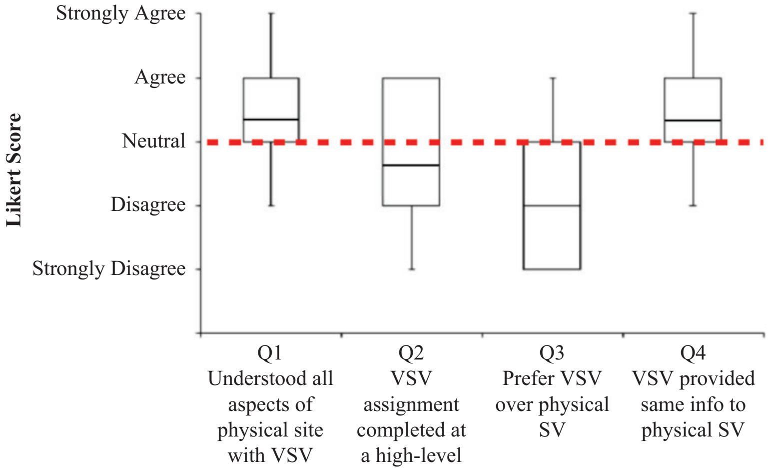

Fig. 3. Box-plot results for questions 1–4

Table 2 shows the minimum and maximum responses and the upper & lower quartiles within the boxes. The question response median is shown by a thin solid line within the boxes. The thick dotted line represents the median response of 'Neutral' to these questions. There were no upper or lower outliers.

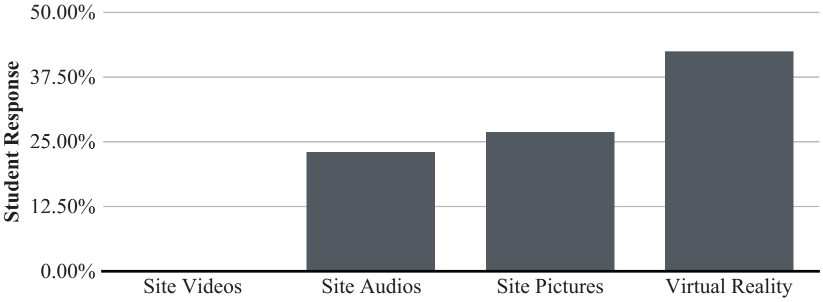

Fig. 4. Results for question 5

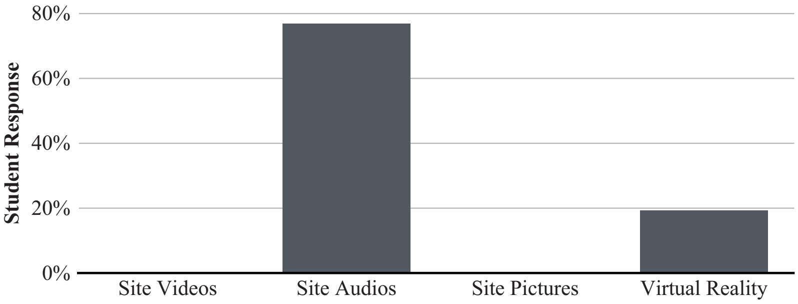

Fig. 5. Results for question 6

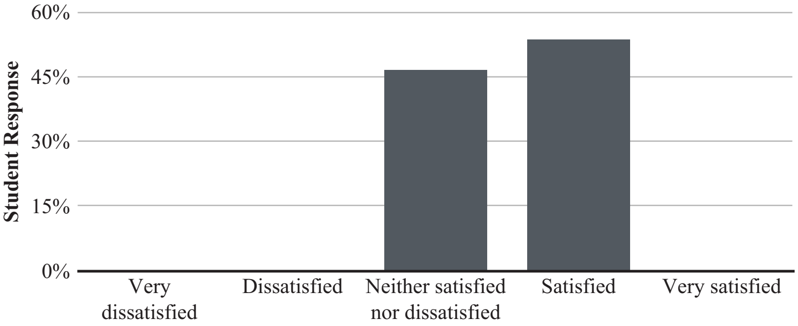

Fig. 6. Results for question 7

Table 2. Results for question 8

Write-in Response
Overall pretty good alternative! Can be a great resource to refer to on top of a physical site visit. Alone, it seems to lack some of the nuances of a real site visit. VR example in Italy was impressive though! That was very close to being there in person.
Under the impact of COVID 19 the virtual site visit is a helpful and safe way to help us have a better understanding of the site. I like the videos most!
It maybe would be better if had a bird’s-eye view.
As a virtual site visit it is useful, especially during an epidemic or when you can’t visit in person.
The virtual reality aspect is more all around, I find sometimes with videos and photos it is hard to link it all together and parts can seem not connected. Having a more immersive experience helps understand the site, the connectivity, and overall understanding.

4 Discussion

The questionnaire results provided an overview of student’s perceptions and opinions on the digital tools provided to complete the assignment and their effectiveness and usability. Though students did not prefer the use of VSV over a physical SV, they noted that the VSV digital tools did provide the same information as a SV and that they felt they were able to understand all aspects of the physical site through the VSV tools provided. These results, coupled with the student's assignment completion, point to ELM's Step 1, experience, and Step 2, comprehension, as an outcome of the VSV delivery. This finding is similar to the use of digital media and VR in a geosciences course where students yielded high rankings for learning experience [2].

The results also indicated trends in student perceptions about specific VSV digital tools as a learning experience. The site pictures and VR images were most 'helpful' in 'understanding the site' with one response noting "*The virtual reality aspect is more all-around, I find sometimes with videos and photos it is hard to link it all together and parts can seem not connected. Having a more immersive experience helps understand the site, the connectivity, and overall understanding.*". The term 'immersive' is often applied to VR contexts and, more specifically, those interactive VR environments such as simulations where an active-user experience is provided (e.g. look and move around). This study did not provide that specific type of 'immersive' data, however it is encouraging that students perceived the multi-scalar, multi-media, and multi-sensory site information provided as inclusive of that quality.

Students noted they did not feel they completed their assignment at a 'high-level' with the VSV digital tools provided, potentially indicating ineffective learning outcomes found within ELT's Step 3 and Step 4. These two Steps synthesized the prior Steps 1 and 2 into applied knowledge. Though other variables exist within these Steps of the ELM, it is important to consider such student perceptions. This result is dissimilar to a prior study where VR in a geosciences course yielded higher perceived learning outcomes when compared to the group which completed an actual site visit [2].

Notable results for the write-in comments included the mention of "safe way to help…better understanding of the site" and that the VSC is considered a "good alternative", "useful" and "helpful". One respondent noted that the "virtual reality aspect if more all-around" which assisted in their "overall understanding" of the site. Overwhelmingly, the write in responses were positive towards the application and use of the VSV tools provided. Lastly, while the result of question 7 pointed to positive responses levels of satisfaction, they do not show overwhelmingly strong positive responses or opinions. There are many potential reasons for this and the research findings must be interpreted as such.

5 Conclusion

5.1 Virtual site visits and the experiential learning model's framework

Results showed that the VSV as a pedagogical tool enables experiential and active learning. As a learning experience, the VSVs theoretical construct and comprehensive digital media activated the learning process through similar constructs as an in-situ site visit. Perception of the site, whether in-situ or through the diverse VSV tools outlined herein, occurred through that VSV experience. Though the context of site visits is spatio-temporal, the VSV indicated it does not detract from the acquisition of site knowledge and dynamics. Student learning outcomes, within the context of the whole class and required assignment (i.e. site analysis map and report), indicated site knowledge was assimilated and that transformation of experience into applied knowledge occurred. Though students did not prefer to engage in the VSV more than the option of a concrete or in-situ experience of a physical site visit, abstract learning, observation, reflection, and conceptualization – important components of Kolb's ELM's Step 1 and Step 2 – occurred as evidenced by the successfully completed student assignments. As noted prior, the assignment required the completion of a landscape management plan and ecological restoration approach to the degraded site and incorporated the synthesis of diverse information, most of which was delivered through the VSV. The successful student assignment submissions also indicated the entire cycle of the ELM was completed by the students as shown in Figure 2.

Specifically, the VSV first required students to engage or enact with the VSV media in order to familiarize themselves with the components and context of the site and landscape. This is considered the 'concrete experience' of Step 1. Step 2's 'reflection' or the initial stages of site analysis was enabled by students being able to re-visit the site via the VSV, if needed, in order to assess various qualities and relationships of the site (e.g. where is best place for wetland ecological restoration). This integrated thought is only capable through the VSV's 'experience'. Next, contextual site ideation, development, and refinement occurs in Step 3, where continued meaning from the VSV experience is synthesized (e.g. what impact will a particular wetland ecological restoration strategy have on other landscape management goals or landscape typologies of the site). Lastly, Step 4's experimentation is actualized through revisiting any of the prior steps, such as engaging in the VSV digital tools, in order to coalesce overall ideas (e.g. best overall management plan). Step 4 required relational insight and can only be achieved through experiential learning's prior steps. Overall, the VSV, like the SV, offered synergistic pathways to effective problem solving and knowledge development.

5.2 Pedagogical implications for natural science and experiential learning

The VSV has traditionally been an integral component of natural science educational curriculum but has applications within other earth sciences and disciplines which require site visits and/or field trips such as urban planning, construction technology, engineering, and geology to name just a few where a site visit or field trip is an important component of experiential learning.

There are strengths and limitations to both approaches as applied to Kolb's ELM. As noted, SVs offer a tangible, physical experience and direct contact with multi-dimensional environmental phenomena through direct observation. VSVs allow for more in-depth multi-scalar analyses and a repeated experience which improves inter-relational context development in addition to learning flexibility and safety to the students. Importantly, using *both* site visit methodologies simultaneously within the class may offer further insight into pedagogical approaches to meet student learning objectives [13], perhaps increasing the learning efficacy of ELM's Steps 1 and 2.

Students indicated they preferred an actual SV compared to the VSV and felt they could not complete the assignments to a high level with the VSV. Though the term 'high-level' was empirically ambiguous, these results may have indicated a level of unfamiliarity and apprehension to the digital tools within the VSV. Future curriculum applications can include a hybrid approach to the site visit where both VSV data and a physical site visit is provided, allowing students to re-visit the site remotely at any time throughout the class [55]. Interestingly, the VSV can be experienced *before* the physical site visit, thus improving the efficiency of the students in the field and allowing focus on specific areas of concern or clarification of data [4], important components of the ELM and Steps 2 and 3.

Developing a measure for pre- and post-VSV would document improvement of learning objective outcomes. Additionally, using the ELM's Steps as a specific learning objective and measure could prove beneficial to pedagogical implementation of VSVs. A more robust exploration of this topic and methodology should be considered, particularly if an understanding of the efficacy of the VSV in improving learning objectives and experiential learning can be gauged effectively. This research provides but one approach to improving virtual experiential learning for which disciplinary and interdisciplinary learning frameworks can be applied.

Questionnaire formats that ask for perceptions of learning outcome feedback should offer an open-ended response to provide insight on their answers and improve the VSV method's efficacy to meet learning objectives. For example, question 2 asked if the student thought that not physically visiting the actual site and using the VSV helped them complete the assignment to a high level. Knowing what particular aspects of the VSV correlated directly to a high- or low-grade would be interesting to know. For example, what Step or Steps within the ELM could be improved. Perhaps more 'active experimentation' within Step 4 is better served by a physical SV.

5.3 Questionnaire limitations

The student sample in this study was not large (n=52) however it did span two separate classes, supporting questionnaire reliability and consistency in its scoring. The results did not assess student satisfaction nor predict or correlate relationships to learning outcomes and success (i.e. criterion-related validity) but simply generalized a set of student preferences and attitudes towards utilizing a comprehensive set of new digital tools. A few questions were predisposed toward positive statements (Questions 1, 2, 4) potentially resulting in unintended response influence or context effect [82] the focus would not be on the content of the question but the positive context of the question format [83].

The instructor, to the best ability, comprehensively documented the site. Though the instructor gathered data for specific 'areas of concern' and prime learning areas, there were likely other areas of data gathering undocumented. As such, there will always be areas which a student may wish to explore in further detail but is unable to without an additional physical site visit by the instructor. Self-reported aspects of student learning, experience, and satisfaction is not an accurate way to measure student outcomes. Though student outcome or improvement was not a direct outcome or measurement within this study, disadvantages exist with self-reporting such as dishonesty, carelessness, and other misleading effects [84]. The questionnaire did not request clarification or justification of student responses such as why they didn't like the audio data and suggestions for improvement.

5.4 Future directions

As shown, the use and application of VSVs are encouraging to meeting both student usability and learning outcome goals within natural sciences curriculum and others. There are many improvements that can be applied to the use of VSV in future uses. Both an in-situ site visit and the ability to reference the VSV materials remotely allow for different learning styles and to assimilate knowledge in meaningful learning outcomes (e.g. grades, quality of assignments.) However, it is not the only tool for learning about a site, the landscape, and its dynamic qualities and any instructor should develop course materials accordingly. Additionally, the VSV could be utilized in traditional curriculum where an actual site visit is provided "*to introduce students to various aspects and develop some of the basic skills needed and to prepare students for going into the field or as follow up exercises after a real field trip*." [85, p. 24].

Future questionnaires should be developed to achieve a larger sample size with modifications based on findings from this questionnaire, academic community discussion, and other resources to assess student use and perceived value of the VSV. For example, what specific learning objectives are supported by the VSV and what are those factors influencing that relationship? What type of comprehension is best enabled by the VSV? Other student behaviors such as frequency of use and length of visit are also important to understand as is a comparative analysis between in-situ and virtual methods.

Additional empirical research is needed to measure efficacy of the VSV, particularly as how it can improve student learning outcomes [86]. A refined application including a more specific set of questions could more clearly begin to establish relationships between the VSV use and variables such as grades, preferences, and learning outcomes.

TEL and virtual learning methods will only become more common in academia. Transmissible disease and personal safety concerns for physical site visits may require such virtual pedagogical frameworks. ICT such as those present in this study's VSV are found in the current practice of many professional and governmental offices and applied within public engagement. Alternative course delivery methods will continue, and, developing a familiarity with interactive ICT such as the VSV and immersive VR may increase student comfortability in unexpected situations, provide accessible and inclusive accommodation, and augment an instructor's teaching repertoire.

The various technologies and tools applied to the VSV must also consider the data collection, not just the data presentation such as photos, VR and others. For example, SV climatological and other experiential qualities may impact learning outcomes as would the VSVs video image quality. VR tools can include 'move-thru' data, a visualization which is different from simple 360-degree views and potentially increasing student engagement. Drone technology is economically viable and should be employed where possible at multiple heights and perspectives, even allowing students to control and analyze independently. As technology advances rapidly, modes for 'complete' engagement of a site visit may include 3-D modeling, adding virtual humans (VH) and augmented reality (AR), as well as aspects of building information modeling (BIM) within infrastructure and projective analyses.

A physical site visit's visceral experience may never be replicated virtually nor be an outright replacement, however this study's multi-scalar, multi-media, and multi-sensory site documentation and delivery through VSV digital tools indicates levels of success in meeting both student usability and learning objectives. The use and application of VSVs in meeting experiential learning outcomes is encouraging. Ultimately, the communication and knowledge sharing between instructor and student will remain paramount, yet such digitally interactive frameworks to enable experiential learning are not disadvantageous.

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7 Abbreviations

ELT, Experiential Learning Theory; ICT, Information and Communication Technology; TEL, Technology Enhanced Learning; VR, Virtual Reality; VSV, Virtual Site Visit; SV, Site Visit; ELM, Experiential Learning Model

8 References

[1] Day, T. (2012). Undergraduate teaching and learning in physical geography. *Prog. Phys. Geogr*. 36, 305–332. https://doi.org/10.1177/0309133312442521

[2] Zhao, J., LaFemina, P., Carr, J., Sajjadi, P., Wallgrün, J. O., & Klippel, A. (2020, March). Learning in the field: Comparison of desktop, immersive virtual reality, and actual field trips for place-based STEM education. In 2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR) (pp. 893–902). IEEE. https://doi.org/10.1109/VR46266.2020.00012

[3] Von Haaren, C., Galler, C., & Ott, S. (2008). Landscape planning. The basis of sustainable landscape development. *Bundesamt für naturschutz/Federal Agency for Nature Conservation, Gebr. Klingenberg Buchkunst Leipzig GmbH*.

[4] Stainfield, J., Fisher, P., Ford, B., & Solem, M. (2000). International virtual field trips: A new direction? *Journal of Geography in Higher Education*, 24(2), 255–262. https://doi.org/10.1080/713677387

[5] Troll, C. (1971). Landscape ecology (geoecology) and biogeocoenology: A terminology study. *Geoforum*, 8, 43–46. https://doi.org/10.1016/0016-7185(71)90029-7

[6] Antrop, Marc, & Veerle Van Eetvelde (2017). Landscape perspectives. *The Holistic Nature of Landscape*. Springer. https://doi.org/10.1007/978-94-024-1183-6

[7] Peci, G. T., Araújo, M. B., Bell, J. D., Blanchard, J., Bonebrake, T. C., Chen, I. C., & Falconi, L. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and hu man well-being. *Science*, 355(6332). https://doi.org/10.1126/science.aai9214

[8] Jolley, A., Hampton, S. J., Brogt, E., Kennedy, B. M., Fraser, L., & Knox, A. (2019). Student field experiences: Designing for different instructors and variable weather. *Journal of Geography in Higher Education*, 43(1), 71–95. https://doi.org/10.1080/03098265.2018.1554632

[9] Tuthill, G., & Klemm, E. B. (2002). Virtual field trips: Alternatives to actual field trips. *International Journal of Instructional Media*, 29(4), 453–468.

[10] Seifan, M., Dada, O. D., & Berenjian, A. (2020). The effect of real and virtual construction field trips on students' perception and career aspiration. *Sustainability*, 12(3), 1200. https://doi.org/10.3390/su12031200

[11] Klippel, A., Zhao, J., Oprean, D., Wallgrün, J. O., & Chang, J. S. K. (2019, March). Research framework for immersive virtual field trips. In *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)* (pp. 1612–1617). IEEE. https://doi.org/10.1109/VR.2019.8798153
[12] Mead, C., Buxner, S., Bruce, G., Taylor, W., Semken, S., & Anbar, A. D. (2019). Immersive, interactive virtual field trips promote science learning. *J. Geosci. Educ.* 67, 131–142. https://doi.org/10.1080/10899995.2019.1565285
[13] Jacobson, A. R., Militello, R., & Baveye, P. C. (2009). Development of computer-assisted virtual field trips to support multidisciplinary learning. *Comput. Educ.* 52, 571–580. https://doi.org/10.1016/j.compedu.2008.11.007
[14] Kolb, D. A., & Fry, R. E. (1974). *Toward an applied theory of experiential learning*. MIT Alfred P. Sloan School of Management.
[15] Özyavuz, M. (2013). Inventory and analysis of the landscape. In *Advances in Landscape Architecture*. IntechOpen. https://doi.org/10.5772/55747
[16] Eiris Pereira, R., & Gheisari, M. (2019). Site visit application in construction education: A descriptive study of faculty members. *International Journal of Construction Education and Research*, 15(2), 83–99. https://doi.org/10.1080/15578771.2017.1375050
[17] Muntean, C. H., Bogusevschi, D., & Muntean, G. M. (2019). *Innovative technology-based solutions for primary, secondary and tertiary STEM education*. Paragon Publishing.
[18] Golubchikov, O. (2015). Negotiating critical geographies through a "feel-trip": Experiential, affective and critical learning in engaged fieldwork. *Journal of Geography in Higher Education*, 39(1), 143–157. https://doi.org/10.1080/03098265.2014.1003800
[19] Frodeman, & Robert. (2003). *Geologic: Breaking ground between philosophy and the earth sciences*. Albany, N.Y.: State University of New York Press.
[20] Bonwell, C. C., & Eison, J. A. (1991). Active learning: Creating excitement in the classroom. 1991 ASHE-ERIC Higher Education Reports. ERIC Clearinghouse on Higher Education, The George Washington University, One Dupont Circle, Suite 630, Washington, DC 20036–1183.
[21] Beard, C., & Wilson, J. P. (2002). *The power of experiential learning: A handbook for trainers and educators*. Stylus Publishing, PO Box 605, Herndon, VA 20172–0605.
[22] Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.
[23] Von Glasersfeld, E. (1989). *Cognition, construction of knowledge, and teaching*. Synthese, 80: 121–140. https://doi.org/10.1007/BF00869951
[24] Kolb, A. Y., & Kolb, D. A. (2012). Experiential learning theory: A dynamic, holistic approach to management learning, education and development. *The SAGE handbook of management learning, education and development*, 42–68. https://doi.org/10.4135/9780857021038.n3
[25] Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2001). Experiential learning theory: Previous research and new directions. *Perspectives on thinking, learning, and cognitive styles*, 1(8), 227–247. https://doi.org/10.4324/9781410605986-9
[26] Dewey, J., & Authentic, I. E. L. (1938). *Experiential learning*. New Jersey: Pentice Hall. Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall, Englewood Cliffs, NJ.
[27] Kolb, D. A. (1984). *Experiential learning*. Prentice-Hall, Englewood Cliffs, NJ.
[28] Wang, T. (2011). Designing for designing: Information and communication technologies (ICTs) and professional education. *International Journal of Art & Design Education*, 30(2), 188–199. https://doi.org/10.1111/j.1476-8070.2011.01675.x
[29] Baker, A. C., Jensen, P. J., & Kolb, D. A. (2002). *Conversational learning: An experiential approach to knowledge creation*. Greenwood Publishing Group.
[30] Tovar, L. A., & Misischia, C. (2018). Experiential learning: Transformation and discovery through travel study programs. *Research in Higher Education Journal*, 35.

[31] Sener, S., & Çokçaliskan, A. (2018). An investigation between multiple intelligences and learning styles. *Journal of Education and Training Studies*, 6(2), 125–132. https://doi.org/10.11114/jets.v6i2.2643

[32] Rienties, B., & Tempelaar, D. (2018). Turning groups inside out: A social network perspective. *Journal of the Learning Sciences*, 27(4), 550–579. https://doi.org/10.1080/10508406.2017.1398652

[33] Ramsden, P. (1998). Managing the effective university. *Higher Education Research & Development*, 17(3), 347–370. https://doi.org/10.1080/0729436980170307

[34] Trygg, K., & Köhler, H. (2015). Exkursion-varför då?. *Geografiska Notiser*, 73(1), 16–22.

[35] Mills, A., Ashford, P., & McLaughlin, P. (2006). The value of experiential learning for providing a contextual understanding of the construction process. AUBEA 2006: Proceedings of the 31st Australasian University Building Educators Association Conference, 1–13.

[36] Holgersen, S. (2021). How to incorporate theory in (urban) field trips: The built environment as concrete abstraction. *Journal of Geography in Higher Education*, 45(3), 361–379. https://doi.org/10.1080/03098265.2020.1833317

[37] Janovy, J., & Major, K. M. (2009). Why we have field stations: Reflections on the cultivation of biologists. *BioScience*, 59(3), 217–222. https://doi.org/10.1525/bio.2009.59.3.6

[38] Manzanal, R. F., Rodríguez Barreiro, L. M., & Casal Jiménez, M. (1999). Relationship between ecology fieldwork and student attitudes toward environmental protection. *Journal of Research in Science Teaching*, 36(4), 431–453. https://doi.org/10.1002/(SICI)1098-2736(199904)36:4<431::AID-TEA3>3.0.CO;2-9

[39] Blinn, N., Robey, M., Shanbari, H., & Issa, R. R. A. (2015). Using augmented reality to enhance construction management educational experiences. Proceedings 32nd CIB W078 Workshop, Eindhoven, The Netherlands, 8 p.

[40] Ohlin, C. L. (2019). Information and communication technology in a global world. *Research in Social Sciences and Technology*, 4(2), 41–57. https://doi.org/10.46303/ressat.04.02.4

[41] Ratheeswari, K. (2018). Information communication technology in education. *Journal of Applied and Advanced Research*, 3(1), 45–47. https://doi.org/10.21839/jaar.2018.v3iS1.169

[42] Sarkar, S. (2012). The role of information and communication technology (ICT) in higher education for the 21st century. *Science*, 1(1), 30–41.

[43] Friess, D. A., Oliver, G. J., Quak, M. S., & Lau, A. Y. (2016). Incorporating "virtual" and "real world" field trips into introductory geography modules. *J. Geogr. High. Educ.*, 40, 546–564. https://doi.org/10.1080/03098265.2016.1174818

[44] Fallon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development*, 1–24. https://doi.org/10.1007/s11423-020-09767-4

[45] Golonka, E. M., Bowles, A. R., Frank, V. M., Richardson, D. L. & Freynik, S. (2014). Technologies for foreign language learning: A review of technology types and their effectiveness. *Computer Assisted Language Learning*, 27(1). https://doi.org/10.1080/09588221.2012.700315

[46] Al-Rahmi, W. M., Alzahrani, A. I., Yahaya, N., Alalwan, N., & Kamin, Y. B. (2020). Digital communication: Information and communication technology (ICT) usage for education sustainability. *Sustainability*, 12(12), 5052. https://doi.org/10.3390/su12125052

[47] Talebian, S., Mohammadi, H. M., & Rezvanfar, A. (2014). Information and communication technology (ICT) in higher education: Advantages, disadvantages, conveniences and limitations of applying e-learning to agricultural students in Iran. *Procedia-Social and Behavioral Sciences*, 152, 300–305. https://doi.org/10.1016/j.sbspro.2014.09.199

[48] Kirkwood, A., & Price, L. (2005). Learners and learning in the twenty-first century: What do we know about students' attitudes towards and experiences of information and communication technologies that will help us design courses? *Studies in Higher Education*, 30(3), 257–274. https://doi.org/10.1080/03075070500095689

[49] More, Y., & Winters, N. (2007). Design approaches in technology-enhanced learning. *Interactive Learning Environments*, 15(1), 61–75. https://doi.org/10.1080/10494820601044236

[50] Goodyear, P., & Retalis, S. (2010). *Technology-enhanced learning*. Rotterdam: Sense Publishers. https://doi.org/10.1163/9789460910623

[51] leBrasseur, R. (2021). Digital review sessions: Student perceptions of digital tablets in design studio review and desk critique. *Landscape Journal*, 39(2), 17–30. https://doi.org/10.3368/wplj.39.2.17

[52] Voogt, J., Knezek, G., Cox, M., Knezek, D. & ten Brummelhuis, A. (2013). Under which conditions does ICT have a positive effect on teaching and learning? A call to action. *Journal of Computer Assisted Learning*, 29(1). https://doi.org/10.1111/j.1365-2729.2011.00453.x

[53] Carver, R., King, R., Hannum, W., & Fowler, B. (2007). Toward a model of experiential e-learning. *MERLOT Journal of Online Learning and Teaching*, 3(3), 247–256.

[54] Davidson, J., Prahalad, V., & Harwood, A. (2021). Design precepts for online experiential learning programs to address wicked sustainability problems. *Journal of Geography in Higher Education*, 1–23. https://doi.org/10.1080/03098265.2020.1849061

[55] Boyle, A., Maguire, S., Martin, A., Milsom, C., Nash, R., Rawlinson, S., & Conchie, S. (2007). Fieldwork is good: The student perception and the affective domain. *Journal of Geography in Higher Education*, 31(2), 299–317. https://doi.org/10.1080/03098260601063628

[56] Barth, M., & Burandt, S. (2013). Adding the "e-" to learning for sustainable development: Challenges and innovation. *Sustainability*, 5(6), 2609–2622. https://doi.org/10.3390/su5062609

[57] Hurst, D. (1998). Use of "virtual" field trips in teaching introductory geology. *Computers & Geosciences*, 24(7): 653–658. https://doi.org/10.1016/S0098-3004(98)00043-0

[58] Argles, T. W., Burden, D., Tilling, S., & Minocha, S. (2017, January). FieldscapesVR: Virtual world field trips to extend and enrich field teaching. In *International Geological Congress, Abstracts* (Vol. 35).

[59] Fung, F. M., Choo, W. Y., Ardisara, A., Zimmermann, C. D., Watts, S., Koscielniak, T., Blanc, E., Coumoul, X., & Dumke, R. (2019). *Applying a Virtual Reality Platform in Environmental Chemistry Education to Conduct a Field Trip to an Overseas Site*; ACS Publications: Washington, DC, USA. https://doi.org/10.1021/acs.jchemed.8b00728

[60] Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, 60, 225–236. https://doi.org/10.1016/j.learninstruc.2017.12.007

[61] Hagge, P. (2021). Student perceptions of semester-long in-class virtual reality: Effectively using "google earth VR" in a higher education classroom. *Journal of Geography in Higher Education*, 45(3), 342–360. https://doi.org/10.1080/03098265.2020.1827376

[62] Pujol-Tost, L. (2011). Realism in virtual reality applications for cultural heritage. *International Journal of Virtual Reality*, 10(3).

[63] Hope, M. (2009). The importance of direct experience: A philosophical defence of fieldwork in human geography. *Journal of Geography in Higher Education*. 33(2), 169–182. https://doi.org/10.1080/03098260802276698

[64] Golubchikov, O. (2015). Negotiating critical geographies through a "feel-trip": Experiential affective and critical learning in engaged fieldwork. *Journal of Geography in Higher Education*, 39, 143–157. https://doi.org/10.1080/03098265.2014.1003800

[65] Wu, J., & Qi, Y. (2000). Dealing with scale in landscape analysis: An overview. *Geographic Information Sciences*, 6(1), 1–5. https://doi.org/10.1080/10824000009480528

[66] Dovey, K., Pafka, E., & Ristic, M. (Eds.). (2017). *Mapping urbanities: Morphologies, flows, possibilities*. Routledge. https://doi.org/10.4324/9781315309163

[67] Zimmermann, A. (2014). *Planning landscape: Dimensions, elements, typologies*. Birkhäuser.

[68] Plottu, E., & Plottu, B. (2012). Total landscape values: A multi-dimensional approach. *Journal of Environmental Planning and Management*, 55(6), 797–811. https://doi.org/10.1080/09640568.2011.628818

[69] Scott, I., Fuller, I., & Gaskin, S. (2006). Life without fieldwork: Some lecturers' perceptions of geography and environmental science fieldwork. *Journal of Geography in Higher Education*, 30(1), 161–171. https://doi.org/10.1080/03098260500499832

[70] Sharp, E. L., Fagan, J., Kah, M., McEntee, M., & Salmond, J. (2021). Hopeful approaches to teaching and learning environmental "wicked problems". *Journal of Geography in Higher Education*, 1–19. https://doi.org/10.1080/03098265.2021.1900081

[71] Çaliskan, O. (2011). Virtual field trips in education of earth and environmental sciences. *Procedia – Social and Behavioral Sciences*, 15, 3239–3243e. https://doi.org/10.1016/j.sbspro.2011.04.278

[72] Qui, W. & Hubble, T. (2002). The advantages and disadvantages of virtual field trips in geoscience education. *The China Papers*, 13, 75–79.

[73] Holton, M. (2017). It was amazing to see our projects come to life! Developing affective learning during geography fieldwork through tropophilia. *Journal of Geography in Higher Education*, 41(2), 198–212. https://doi.org/10.1080/03098265.2017.1290592

[74] Blomberg, J., Giacomi, J., Mosher, A., & Swenton-Wall, P. (2017). Ethnographic field methods and their relation to design. In *Participatory design* (pp. 123–155). CRC Press. https://doi.org/10.1201/9780203744338-7

[75] Spicer, J. I., & Stratford, J. (2001). Student perceptions of a virtual field trip to replace a real field trip. *J. Comput. Assist. Learn*.17, 345–354. https://doi.org/10.1046/j.0266-4909.2001.00191.x

[76] Eiris, R., Wen, J., & Gheisari, M. (2020, November). iVisit: Digital interactive construction site visits using 360-degree panoramas and virtual humans. In *Construction Research Congress 2020: Computer Applications* (pp. 1106–1116). Reston, VA: American Society of Civil Engineers. https://doi.org/10.1061/9780784482865.117

[77] Wilkins, B., & Barrett, J. (2000). The virtual construction site: A web-based teaching/learning environment in construction technology. *Automation in construction*, 10(1), 169–179. https://doi.org/10.1016/S0926-5805(00)00075-3

[78] France, D., Whalley, W. B., Mauchline, A., Powell, V., Welsh, K., Lerczak, A., Park, J., & Bednarz, R. (2015). Pre-field trips and virtual field trips. In *Enhancing Fieldwork Learning Using Mobile Technologies* (pp. 101–114). Springer, Cham. https://doi.org/10.1007/978-3-319-20967-8_7

[79] Litherland, K., & Stott, T. A. (2012). Virtual field sites: Losses and gains in authenticity with semantic technologies. *Technology, Pedagogy and Education*, 21(2), 213–230. https://doi.org/10.1080/1475939X.2012.697773

[80] Ramic-Brkic, B., & Chalmers, A. (2010, June). Virtual smell: Authentic smell diffusion in virtual environments. In *Proceedings of the 7th International Conference on Computer Graphics, Virtual Reality, Visualisation and Interaction in Africa* (pp. 45–52). https://doi.org/10.1145/1811158.1811166

[81] Obrist, M., Tuch, A. N., & Hornbaek, K. (2014). Opportunities for odor: Experiences with smell and implications for technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2843–2852). https://doi.org/10.1145/2556288.2557008

[82] Schwarz, N., & Strack, F. (1990). Context effects in attitude surveys: Applying cognitive theory to social research. *European Review of Social Psychology*, 2, 31–50. https://doi.org/10.1080/14792779143000015

[83] Sudman, S., Bradburn, N. M., & Schwarz, N. (1996). *Thinking about answers: The application of cognitive processes to survey methodology*. Jossey-Bass.

[84] Borg, W. R., & Gall, M. D. (1983). Educational Research.

[85] Gilmour, I. (1997). Skiddaw virtual field trip. A study of thermal metamorphism. (http://earth2.open.ac.uk/Skiddaw/Text/Skiddaw.html) from: https://www.researchgate.net/publication/ 237405940_International_Virtual_Field_Trips_a_New_Direction [accessed Aug 09 2021].

[86] Corwin, L. A., Graham, M. J., & Dolan, E. L. (2015). Modeling course-based undergraduate research experiences: An agenda for future research and evaluation. *CBE—Life Sciences Education*, 14(1), es1. https://doi.org/10.1187/cbe.14-10-0167

[87] Shi, J., Honjo, T., Zhang, K., & Furuya, K. (2020). Using virtual reality to assess landscape: A comparative study between on-site survey and virtual reality of aesthetic preference and landscape cognition. *Sustainability*, 12(7), 2875. https://doi.org/10.3390/su12072875

9 Appendix

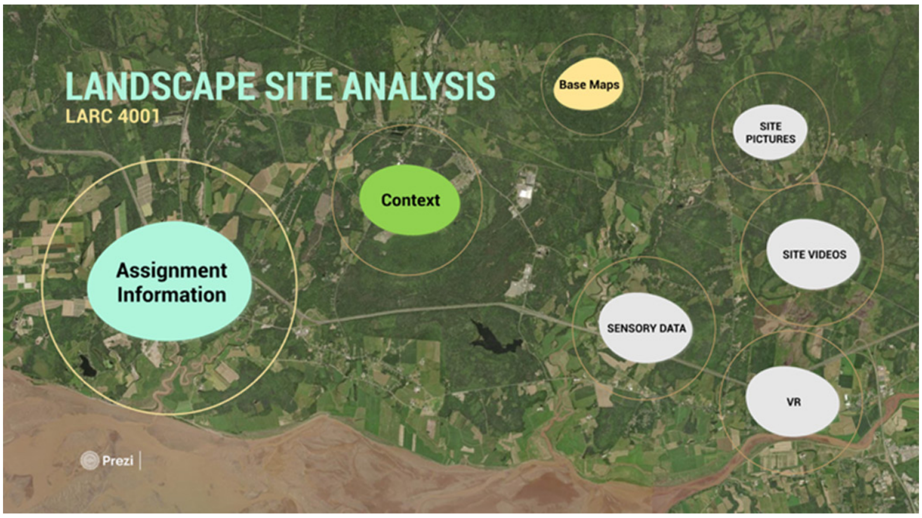


Fig. A1. The first page of the interactive web site showing the organization of the assignment and site visit information

MULTI-SENSORY

1. ACADIAN REMNANT FOREST
2. SMALL WETLAND IN FLOODPLAIN
3. CENTER OF RUNWAYS
4. FOREST
5. MASSTOWN ROAD ENTRY
6. WETLAND AND INTERMITTENT GRASSLANDS
7. RECREATIN TRAIL
8. FOREST NEAR INDUSTRIAL CENTER

Fig. A2. Eight diverse locations were chosen to provide comprehensive site documentation. The instructor was responsible for determining the locations and those site characteristics to include, purposefully choosing a diversity of overall landscape character locations and unique or noteworthy environments

6. INTERMITTENT WETLAND AND GRASSLAND

Fig. A3. Organization of experiential site analysis data for one area of the larger site

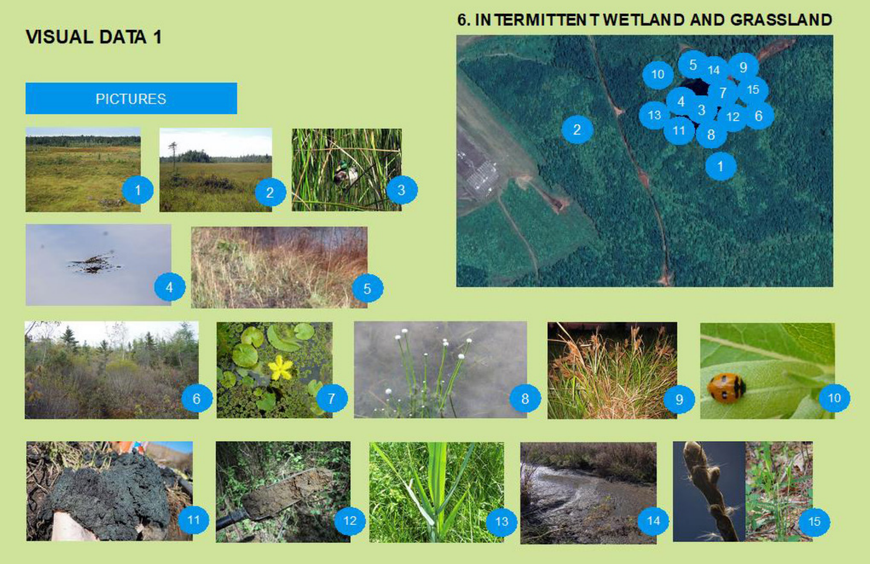
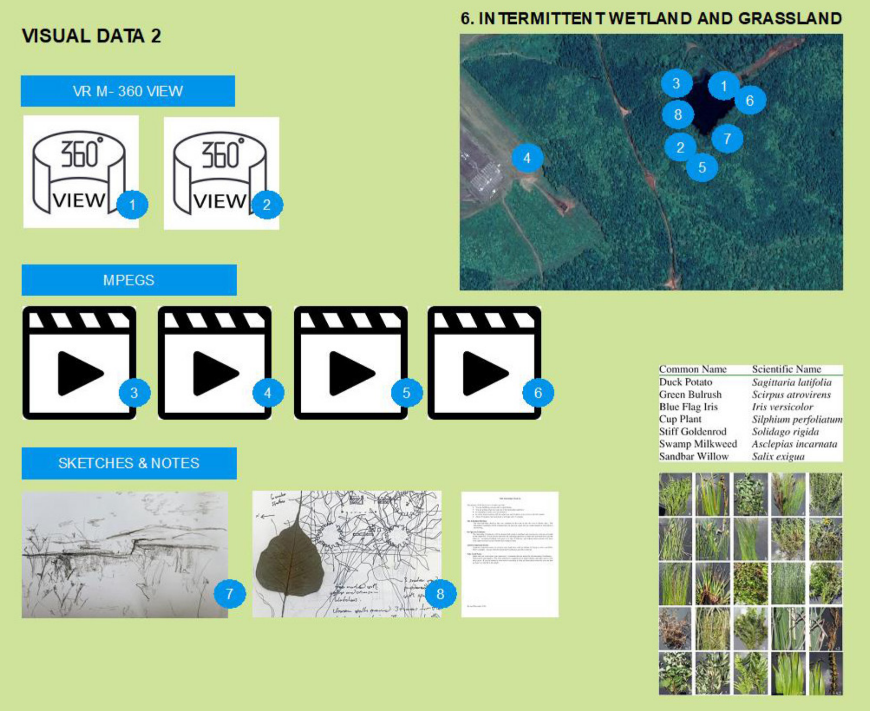


Fig. A4. Visual data, page 1 of 2. Each photo is clickable and interactive to allow for the full screen view and/or download



Common Name	Scientific Name
Duck Potato	*Sagittaria latifolia*
Green Bulrush	*Scirpus atrovirens*
Blue Flag Iris	*Iris versicolor*
Cup Plant	*Silphium perfoliatum*
Stiff Goldenrod	*Solidago rigida*
Swamp Milkweed	*Asclepias incarnata*
Sandbar Willow	*Salix exigua*

Fig. A5. Visual data, page 2 of 2. Each item is clickable and interactive to allow for the full screen view and/or download

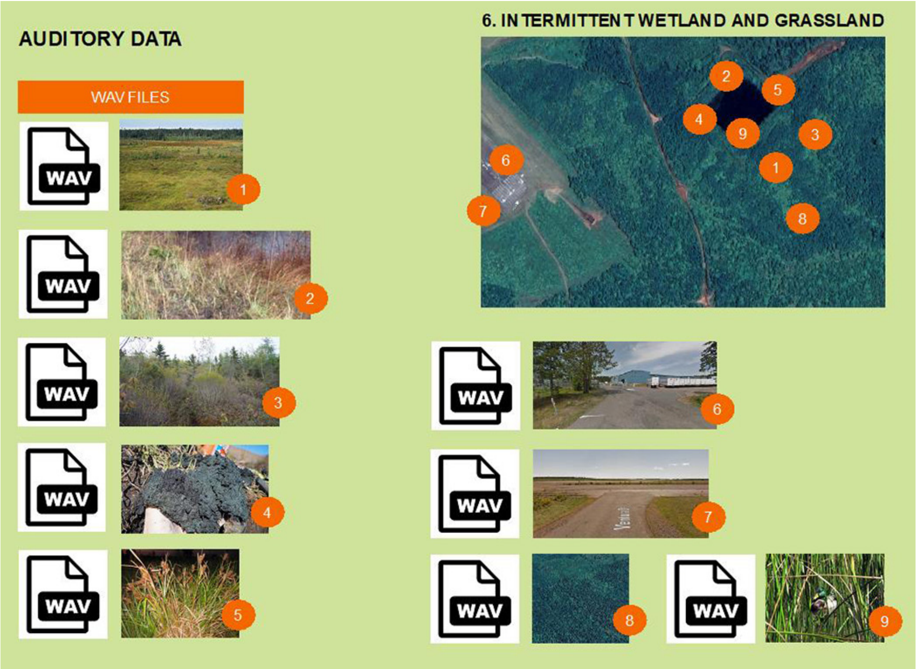


Fig. A6. Sound data

10 Author

Richard leBrasseur, PhD is an Assistant Professor in the Department of Plant, Food and Environmental Sciences at Dalhousie University in Nova Scotia, Canada. He is Director of the interdisciplinary Green Infrastructure Performance Lab (www.gipl.land). (email: r.lebrasseur@dal.ca)

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