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Applying a Virtual Reality Platform in Environmental Chemistry Education To Conduct a Field Trip to an Overseas Site

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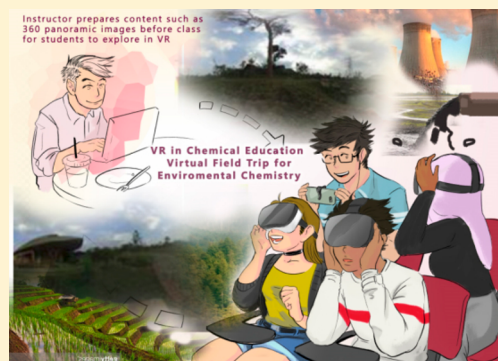
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Supporting Information

ABSTRACT: Field trips are a common activity for instructors to engage students and give them a first-hand understanding of a subject, especially in environmental chemistry. However, the planning and execution for a field trip is logistically challenging and demanding of human and material resources. Here, we demonstrate the conduct of a virtual overseas field trip for 74 students with the use of a web-based virtual reality (VR) application. From the feedback after the virtual field trip, students reported general receptiveness toward such use of VR technology.



KEYWORDS: Upper-Division Undergraduate, General Public, Demonstrations, Analytical Chemistry, Environmental Chemistry, Computer-Based Learning, Internet/Web-Based Learning, Multimedia-Based Learning, Second-Year Undergraduate

Field trips are commonly used activities for environmental teaching.¹ They are a great way for instructors to engage students and give them a first-hand understanding of a subject.^{1–3} However, the execution for a field trip in a compact schedule renders it logistically challenging and resource-intensive. On top of that, it is common for students and instructors to have back-to-back lectures. As such, the tight schedule restricts the implementation of a local field trip, let alone an overseas one. The lack of visual engagement with the environment deprives students who are interested in seeing the real scene in the environment to stimulate critical thinking.⁴ Here, we document the use of a virtual reality (VR) field trip with the use of the individual VR gear for their own exploration

to a real site where the 360° photos are captured by the instructor.

OVERVIEW ON VIRTUAL REALITY USAGE IN ENVIRONMENT NAVIGATION

In this technology report on applying a virtual reality platform for chemical education, the following technical terms will be used repeatedly. We have defined the meaning of these terms as follows:

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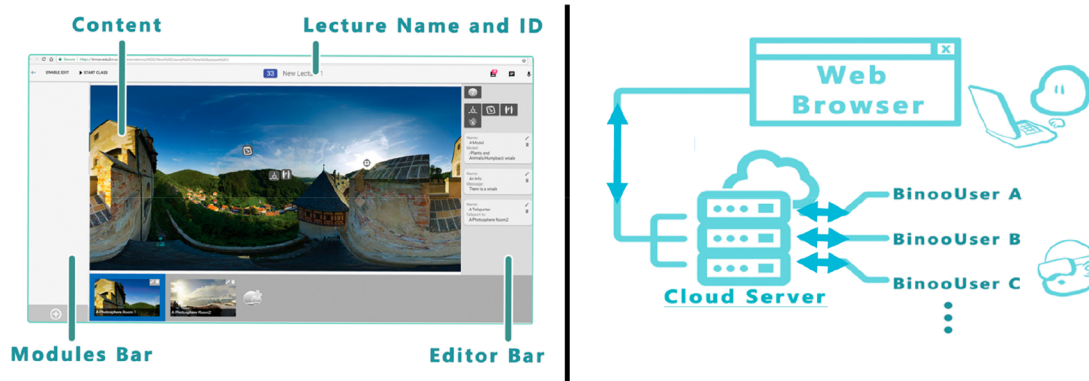


Figure 1. (Left) Screenshot of the teacher console. The classes can be customized with resources from the local library or their own resources. In the picture above, the editing environment for photospheres is shown. (Right) The instructor access to the VR editor via a web browser. The VR classes are stored on a cloud server. Multiple students can access the VR content with a smartphone. Interface image reproduced with permission. Copyright 2018 EduVR.



Figure 2. (Left) View of the Binoo using the VR mode. The split screen shows two pictures for each eye. By doing so it creates an immersive environment. (Right) VR gear: goggle (A) and lenses (B). Binoo images reproduced with permission. Copyright 2018 EduVR.

- Photospheres, 360° images filmed by a 360° camera (in our project, the camera used was Ricoh Theta S)
- Panopticon, the immersive 360° view experienced by individual student
- edu2VR, the 360° VR online platform used to house the photospheres
- Binoo, the mobile application from edu2VR to access the photospheres
- Module, the VR class with a unique ID for students to join the virtual field trip
- Element, 3D objects, annotations, quizzes and teleporter embedded in the photospheres
- VR gear, VR goggles/lenses

The image-based approach to virtual environment navigation has gained global prominence ever since its debut in 1994.⁵ Since then, virtual navigation has seen an expansion of applications, ranging from enhancing consumer experiences to exploring the geological environment.^{6–8} There are numerous research studies exploring the potential benefits of engaging VR in education. From a pedagogical perspective, having VR has many advantages. Case studies have shown that VR can manifest a virtual environment close to the actual environment where learning about the real/actual environment can take place at a fraction of the cost of a conventional field-course.⁹ This benefit potentially manifests itself in a variety of applications. Lunsford and Slattery incorporated two field trips for their environmental science course, with each session lasting 36 h.¹⁰ Forest and Rayne integrated at least one field

trip in each semester for their first-year chemistry undergraduates.¹¹ They reported difficulties in assessing students on the basis of field trips due to the scheduling that renders the field trips optional for students.¹¹ Elsewhere, Miles and Borchardt revamped their food and cooking course with the inclusion of a group excursion.¹² Both Malbrecht's and Pullen's groups also placed field trips in courses to enhance students' learning.^{13,14} Student feedback indicated a positive experience from the field trips.^{11–14} Here, our report describes the use of a web-based VR online platform, edu2VR, to simulate a field trip to an overseas site for a group of third- and fourth-year undergraduate students.

Field Trip in an Environmental Chemistry Course

In a typical environmental chemistry course at the National University of Singapore (NUS), there are approximately 90 students. The course comprises twice-weekly 2 h lecture, and a 1 h tutorial class. The classes are conducted for 13 weeks.¹⁵ Students usually have back-to-back classes, either within walking distance or via travel by bus for about 15 min. Therefore, the unfavorable schedule makes it difficult to arrange a field trip during the academic hours. Some instructors in the past have experimented setting aside a Saturday for such field trips. However, since the university does not usually have academic activities during the weekend, it seems unfair to deprive students of such learning opportunities.



Figure 3. Students viewing the virtual field trip via the VR goggle (left) and lenses (right).

In our pilot project, edu2VR assisted teaching by providing students with access to photospheres of a rural region, Ungaran, in Indonesia. The instructor uploaded these photospheres prelecture. During lecture, the instructors guided students via their own panopticon in a field trip study. Afterward, students had to answer questions regarding the environment.

About the VR Technology Application

This VR technology has two components: (1) The first is a web-based editing and authoring tool that helps the educators control their VR classes (Figure 1, left). Here, instructors create and edit the classes for virtual excursions. It is possible to guide the students along the VR learning experience or let the students explore the VR content in a self-paced manner. (2) The second is a mobile application (app). With this app, the students are able to enter specific VR classes by using their smartphones.

The edu2VR platform is hosted on a cloud server, and the VR content is accessible from anywhere (Figure 1, right). The instructor and student do not necessarily have to be at the same physical location. The content created by the instructor is stored on the server. The students view the content on Binoos either in the VR mode or normal mode. VR goggles/lenses for smartphones are needed for the VR mode (Figure 2, left), whereas viewing in the normal mode requires only the smartphones. The VR mode is the preferred viewing mode as the student will be immersed in the content via the VR gear (Figure 2, right).

Features of VR Field Trip

Photospheres form the backbone of the VR field trip. Students are immersed in environments governed by the sequence of photospheres. A series of photospheres can be connected via “teleporter”, an element in the app that allow the student to move from point A to point B. This element allows the students to explore an environment at their own pace if they wish.

The major advantage of the VR field trip is creating an immersive environment for the students without incurring high logistical costs and time. In edu2VR, 360° video and 2D videos can be incorporated into the module. Third party 360° videos hosted on YouTube can be also be embedded. During the guided VR field trip, the instructor has the possibility of directing students to the specific photosphere to highlight important scenes.

■ PREPARATION AND EXECUTION OF VIRTUAL FIELD TRIP

Prior to the virtual field trip class, the instructor films a set of photospheres at the excursion site. The instructor then creates a module on the teacher console. Each module has a unique ID. The instructor then uploads the photospheres on the module, inserts the teleporter elements, and creates labels or commentary to annotate the field trip sites.

Immediately before the virtual field trip, students are provided with either a large VR goggle or a small VR lens (Figure 3). To join the virtual field trip, the students have to install Binoos on their smartphones. Once the app is opened, the students key in the class ID provided by the instructor. Inside the VR environment the students can rotate their heads to view the whole environment. Students interact with the VR environment by staring at the element until a timer counts down or by selecting the element via staring and then gently tapping the VR goggle.

■ METHODOLOGY

This VR field trip was carried out on a cohort of 74 third- and fourth-year chemistry students over the duration of two lessons across 3 weeks, each ranging from 1 to 1.5 h in duration. The course code/title is CM3261/Environmental Chemistry.¹⁵ The first lesson's objectives were to introduce the idea of VR in the classroom setting and to allow students to familiarize themselves with both the VR gear and Binoos app. During the first lesson, the instructor led the students through the various photospheres and elements (class ID: 114 and 131). Then, students were then left to explore the virtual site for themselves.

For the second lesson, students were given the class ID “133” to access the virtual field trip. The class ID “133” corresponds to the module containing the set of photospheres filmed in Ungaran. During the lesson, the instructor directed students to specific areas of the photosphere to draw further emphasis to specific areas of interest. Students were then allowed to explore the field trip on their own (Figure 4). After the second lesson, students were then required to answer environmental chemistry questions regarding their field trip (see Supporting Information).

■ POST-VR FIELD TRIP ANALYSIS

After conducting the second VR class, a voluntary anonymous survey was posted to gather feedback on using the Binoos (response rate: 80%). The feedback primarily revolved around the enthusiasm toward the first use of VR in a chemistry course



Figure 4. Students immersed in the virtual field trip at their own pace.

at NUS. On a Likert scale of 1–5, students rated their virtual field trip experience (Table 1).

Table 1. Students' Perceptions Regarding the Virtual Field Trip

Question for Student Response	Responses by Score, ^a N (Total N = 59) ^b					Combined Categories, ^c %	
	5	4	3	2	1	5 + 4	2 + 1
On a scale from 1 to 5, how would you rate your experience based on today's virtual field trip class?	5	33	14	6	1	64	12

^aThe scores from 5 to 1 represent the following agreement levels: "very good"; "good"; "neutral"; "poor"; and "very poor", respectively. The total number of responses for each level of agreement are tabulated. ^bResponse rate = 80%. ^cThe combined category "5 + 4" represents the percentage of students responding with "very good" and "good"; the category "2 + 1" represents the percentage of students responding with "poor" and "very poor".

DISCUSSION AND CONCLUSIONS

The data suggest that the students were generally receptive toward the use of the VR technology in the virtual field trip. Several pieces of qualitative feedback were received and are extracted:

Maybe there could be a zoom function to allow an up close on certain things we might be interested in. Because some things could not be seen clearly.

To be honest, I feel that the experience was really fun and I really appreciate the time spent for this VR experience to take place because we rarely get to experience such thing.

We experience disorientation in VR. Other than that it is quite interesting/fun.

From a user experience perspective, the main challenges faced were disorientation and app limitations. The reported disorientation could be caused by the 15 min virtual excursion that was conducted without intervals. A possible solution is to punctuate the session into 5 min chunks. In this way, students can afford a break from the virtual world, look into the real world, and return to the virtual excursion when ready. Some older smartphones were incompatible with Bino. Due to the lack of functionality such as a zoom element, students were unable to clearly view certain images or objects within the photospheres. A possible workaround is to check the mobile app that is monitoring the recording to preview that the 360° camera captures all salient objects, as reported by Ardisara and

co-worker.¹⁶ Nevertheless, a majority of the students gained a positive experience. Currently, there are several free online VR platforms to create an immersive experience. Besides edu2VR, the companies offering these services include uptale.io, InstagVR, Headjack, and VeeR.^{17–20} Educators who are keen on creating a virtual excursion for their students can utilize these platforms. Similar to edu2VR, instructors are not required to possess coding skills. In the same way, these online platforms allow users to upload photospheres and 360° videos, and they provide annotating ability. With the use of VR, educators are able to conduct a field trip, circumventing logistical and cost problems. In conclusion, here we have demonstrated the application of a web-based VR online platform to simulate a field trip to an overseas site for a group of third- and fourth-year undergraduate students.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.8b00728.

Document showing the photospheres used in the virtual field trip and the environmental questions based on the virtual field trip, with the URL link to the edu2VR demo and tutorial guide for new users on how to create their virtual field trips (PDF)

"How-to" user manual on using the Bino app (PDF)

"How-to" on the recording of photosphere using a low-cost 360-camera (PDF)

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Notes

The authors declare no competing financial interest.

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