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Self-guided field trips allow flexibility in undergraduate student introductory field experiences

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ABSTRACT

There is a clear desire in the geoscience community to engage students in field work in ways that minimize institutional (cost, size, liability) and circumstantial barriers (family obligations, financial burdens) that decrease field trip participation at the introductory level. Here we demonstrate that non-major students want accessible field experiences; however, concerns over time and transportation limit students' ability to engage in field trips outside of class time, even when offered. We used the free NSF-funded Flyover Country mobile app to create self-guided field trips to regional parks and urban areas with geological features of interest. These trips were implemented in a small, non-major focused, Introduction to Geology course which had previously experienced poor attendance for field trips outside of class time. We then compared experiences of students using the app to experiences of students in the same course who attended a traditional instructor-led trip. Lab grades and student survey responses provide evidence that students on the self-guided field trips observed similar geology and reported similar affective outcomes as those students who attended the instructor-led trip. While outcomes at the Introductory level suggest a self-guided modality is a promising option, results may vary for more technical upper division courses.

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Introduction

Field experiences are an important and often formative part of undergraduate geoscience curricula (Boyle et al., 2007; Mogk & Goodwin, 2012; Petcovic et al., 2014; Whitmeyer et al., 2009) and introductory level field work can have positive impacts on learning gains (Elkins & Elkins, 2007). A majority of geoscience graduates at U.S. undergraduate institutions report deciding on their major sometime in their first two years of undergraduate coursework, making impactful introductory courses an important recruiting tool (Kortz et al., 2020; Wilson, 2017). Overall field trip and field course participation has been high at the undergraduate level, with most undergraduate students reporting they have taken several courses with significant field components by the time they graduate (Wilson, 2017).

Introductory level field experiences, however, are often difficult due to large class sizes and other institutional barriers as well as time constraints and other personal barriers for individual students. Students who carry heavy loads of responsibility outside of school, due to family or financial circumstances, for example, are particularly affected, and this time constraint tends to have higher impact for first-generation students and students from backgrounds underrepresented in higher education (Warburton et al., 2001). Using a self-guided field trip allows students to access the same material in the same field locations, but asynchronously. This flexibility allows students with complex school-life balance increased flexibility to take trips at a time that works best for them, allows students who are mobility limited to move at their own pace, and allows large enrollment courses to send students in small groups.

Here we first ask three questions about the motivation for introductory non-major students to attend field trips (1) Do students in a non-majors introductory geology course want to attend field trips? (2) Why do non-major students in our introductory geology course typically choose not to attend 'traditional' field trips held during non-class hours? and (3) When given a choice, will students prefer to attend field trips in-person or using a self-guided trip app? We then test the outcome of offering the self-guided trip, asking (1) Are content outcomes similar between the two modes and (2) Are affective outcomes, including enjoyment and connection to the location, similar for the two trip types?

Background

Institutional and course context

The University of Washington, Bothell (UWB) campus is one of three campuses in the UW system. The approximately 5000 undergraduate students enrolled in the 2017-18

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academic year were comprised of nearly 50% first-generation students, 40% Pell Grant-eligible students,[1] and 16% Under Represented Minority (URM) students, 37% white/Caucasian students and 29% Asian students with the remainder unidentified or identifying two or more races ("University of Washington, Bothell," n.d.). The campus does not offer a Geology major and the Introduction to Geology course is optional for Environmental Science majors; consequently, the course enrolls largely non-STEM major students who are seeking a science distribution requirement. While racial and socio-economic demographic data were not collected in this survey, the broad enrollment for the courses tends to make it reflective of the campus as a whole.

Course learning objectives cover a range of content knowledge typical of Introductory Geology and also include the following objectives:

1. Students will be able to describe and provide examples of ways that Earth systems interact with and significantly affect human systems.
2. Students will be able to distinguish between observation and interpretation in Earth systems and be able to provide examples of both in field and classroom settings.

In initial offerings of the course, beginning in 2014, local field trips to landslide-prone areas, volcanic features and lahar deposits, and glacially formed landscapes were a required class assignment and provided a key means for meeting these learning objectives. Due to course schedule limitations and campus location, there are few locations of interest that can be visited during class meetings. Trips were held on weekend days, typically for 1–3 hours; field trip dates and locations were posted on the first day of the course. A written report option on a similar landscape feature was provided for those who could not attend. Over 3 years and 5 sections of offerings (2014–2017) with alternate dates and requirement levels the student participation rate never exceeded 50%, meaning at most half of the class was meeting at an off-campus field location to participate in the activity as designed to meet the course learning objectives.

Learning objectives for course field experiences

Stated learning objectives for each field trip included content-related objectives related to the specific location, for example, 'to describe the energy of deposition in a sedimentary deposit through examination and description of the material' or 'to describe the impact of glacial erosion and deposition on patterns of urban development today'. All field trips offered in the course also shared common objectives including:

1. to recognize and describe the complexity and scale of real-world geologic landforms and
2. to describe the role of geologic processes in the formation of local environments.

While many, if not all, of these learning objectives could be met to various degrees through classroom activities or virtual field trips rather than actual field excursions, there are also unstated objectives that the instructor hoped will be met through these trips. The following objectives were not stated or assessed through formal or informal means, but underlie the desire to include out of classroom field trips in the curriculum:

1. fostering an increased interest and engagement with understanding the natural world, particularly in local contexts.
2. increasing the likelihood that a student will continue to explore local parks and landscapes.
3. increasing the positive associations with the course and the topic.

The intention of the development of app-based self-guided field trips was to meet both sets of learning objectives above by increasing student participation in the field experience.

Alternatives to 'classic' field experiences

Others have noted the challenge of taking students on field trips due to large enrollment courses, liability concerns and other institutional barriers (Kirkby, 2014; Lenkeit Meezan, 2012) as well as barriers to field trip participation for students with physical and cognitive differences that may limit participation (Carabajal et al., 2017; Gilley et al., 2015) . Many instructors have explored virtual field trips and simulated field experiences as options to field trips outside of class time. Virtual field trips can offer rigorous and engaging experiences leading to demonstrated learning gains and have increasing potential to simulate the complexity and skill development of field-based learning (Dolphin et al., 2019; Mead et al., 2019). Virtual field trips can improve accessibility for students and offer a platform for active learning in the classroom, either as a substitute or a supplement to outdoor field trips. Simulated field trips using active field skills and/or mobile gaming in contrived environments also offer a means to meet many objectives common to introductory geology courses (Bursztyn et al., 2017)

However, there remain some limitations to what can be offered in a virtual or simulated environment. Virtual field trips often suffer from issues of scale, for example, where students report uncertainty or lack of awareness about the relationship of a virtual field site to a larger context (Cliffe, 2017). Immersive technologies hold some promise for integrating 3 D and more experiential tactile questions into virtual trips, but for now most virtual experiences lack these features (Klippel et al., 2019). Since students assigned a self-guided field trip at an actual outcrop are physically present at sites, instructors may ask students to collect samples (such as sediment), compare samples from different locations, or have other hands-on experiences not available on

[1]Pell grant eligibility is determined by family income status. Most grants go to families making less than $30,000 per year, with some going to families making $30-60,000 per year.

virtual trips. Additionally, students using self-guided field trips have the benefit of experiencing learning about their local parks, seeing wildlife and other natural phenomena not associated with the designed content, and an overall positive connection with the experience of going outside, all important to the affective development in student learning (McConnell & van der Hoeven Kraft, 2011; van der Hoeven Kraft et al., 2011).

Design of a field trip in flyover country®

The NSF-funded Flyover Country app (flyovercountry.io, flyovercountry.app; Birlenbach et al., 2019; Myrbo et al., 2018) is one of several apps that can support students in self-guided explorations. Flyover Country uses embedded open-source data from over 10 data providers including interactive geologic maps from Macrostrat.org, fossil locations from Neotomadb.org and Paleobiodb.org, landscape features from Wikipedia.org, Holocene volcano information from the Smithsonian Institution, and more. These datasets are visualized on various base maps, including satellite and elevation-model views. The app uses the mobile device's location services to locate the user relative to these various data sources and field guide stop locations. Flyover Country was initially conceived as a tool to learn about the landscape below from an airplane window seat, but the app now includes a ground-based driving/walking mode as well (Figure 1).

Published field trips, for example from past Geological Society of America meetings, are available in the app and users, including educators, can also create custom trips through a webform that can be accessed at z.umn.edu/fcfg, where step-by-step guidance is provided on how to input and arrange information (Figure 2). Field trip guides can be found in the app by text search or location-based search. Field trips in Flyover Country consist of photos, figures, and text linked to locations (stops can be points, lines, or polygons). All content, including figures, base maps, and other data layers, can be optionally cached for offline use in the app by following the in-app prompts, so students can use the app while online or download the path to use offline if data access is limited or expensive. Using an interface similar to many popular mapping applications, students can

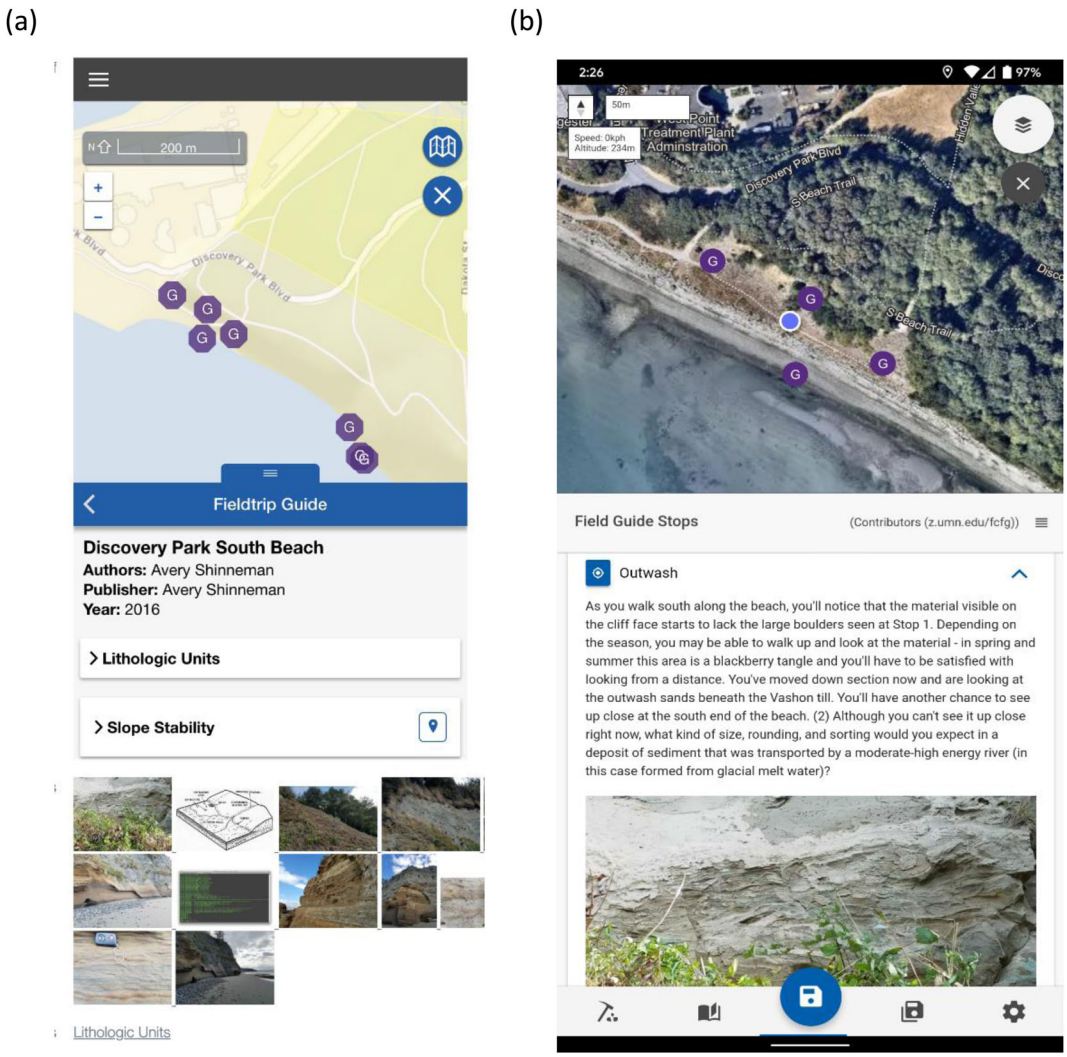

Figure 1. Screenshots from a student view of a field trip in the Flyover Country app. Panel (a) shows an overview with all stops in the trip ('G' hexagons) and available photos and figures. Panel (b) is a view at a single stop with example text and image. All field trips in the app, including the three described here, can be located using the rock hammer menu icon in the lower left of panel (b).

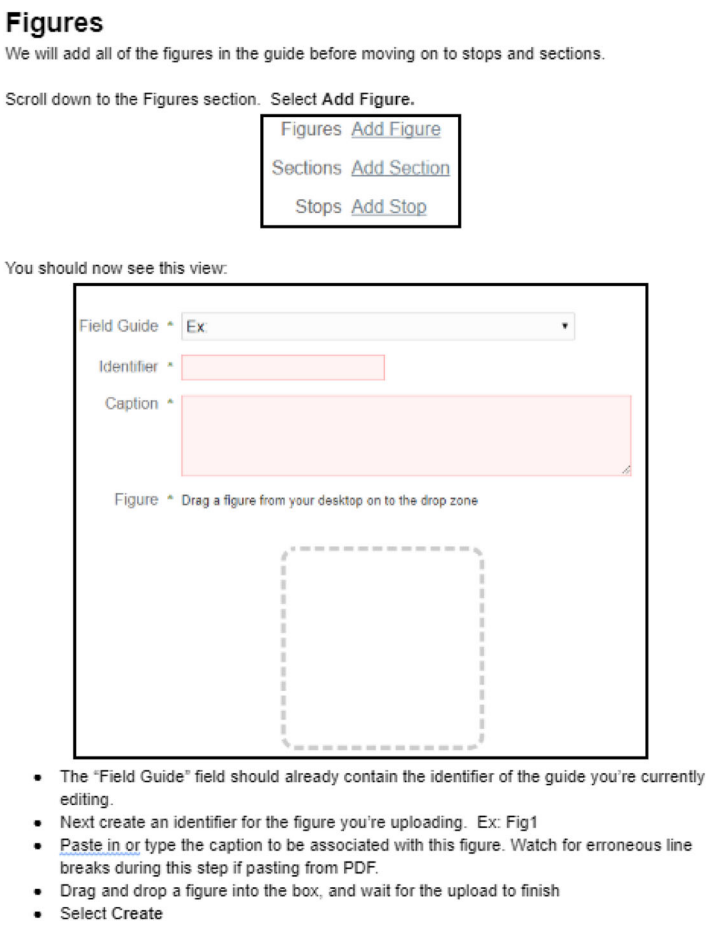

Figure 2. Screenshot from an instructor view of the tutorial available at https://bit.ly/2PR6ls7 to guide input of new trip information. Trips can be at any scale from short walking trips near campus to driving trips that cover long distances and multiple regions.

locate field trip locations and are prompted to look in the right places to see the field trip content that would otherwise be pointed out by an instructor (Figure 1).

Study design

To assess student's initial interest in field experiences as well as their perception of barriers toward field trip participation, students in each course section (Spring 2017, Spring 2018, Fall 2018) were given the following prompt on the first day of class and asked to free-write responses for 5 minutes:

> This quarter you'll be asked to visit at least 2 sites outside the classroom to look at geologic features in natural and/or urban settings. The intention is to give you a chance to connect what we learn in class with real-world geologic settings. What is your initial reaction to knowing we'll explore some of these topics on field trips, either on your own or in groups? If you have positive reactions, negative reactions, questions, or concerns, please note them here.

The prompt was read aloud and displayed on a slide at the front of the room. No information about the structure of the course or required field experiences was given before the writing exercise and the students had not yet received a syllabus.

Following the initial writing exercise, students were given information in class and through the course learning management system (Canvas) about how to download and access free, self-guided field trips in Flyover Country and given the option to take 2 approximately two-hour field trips on specific weekend or weekday afternoon dates during the quarter or to take the same trips on their own using the app at any time during the quarter. All trips described here remain available in the app searching by location or the first author's name.

One trip was located in downtown Seattle, examining historic building stones. The downtown locations are all within a loop that comprised slightly less than a mile of walking and is about 20 miles from campus (25–75 minutes by car depending on traffic). The second trip was located at Discovery park in north Seattle, along Puget Sound. The Discovery park locations are located along an approximately $\frac{1}{2}$ mile walking trail and is also located about 20 miles from campus (30-80 minutes by car). The final trip option visited several sites across an approximately 6 miles stretch of north Seattle that were all within blocks of a major bus line. These sites were less than 10 miles from campus (15–45 minutes by car). In the Spring quarter of 2018, students also had the option to visit the natural history museum on the University of Washington Seattle campus, located 12 miles from the University of Washington Bothell campus (20–60 minutes by car). Because traffic in the Seattle metropolitan area can be significant, the student's choice of travel time (evening v. weekend) may have significantly impacted their experience. Students were reminded periodically about the field trip requirement which was due by the last day of the quarter. In-person and app-based field trips asked the same

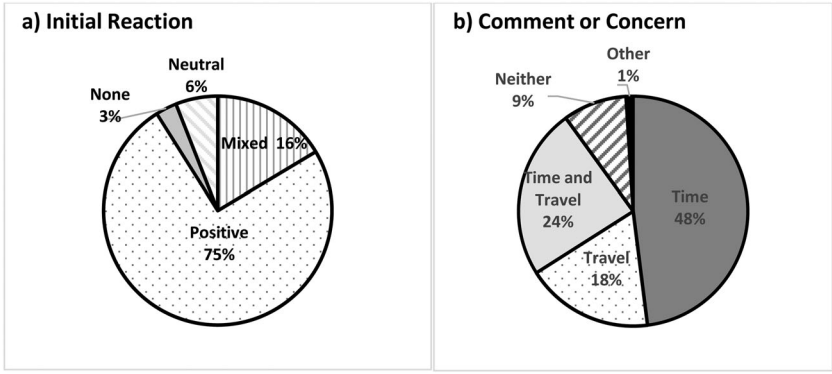

Figure 3. Responses to written prompt on the first day of class asking for reactions to the requirement for field trips in the course. Panel (a) categorized answers to the first question in the prompt, "*What is your initial reaction to knowing we'll explore some of these topics on field trips, either on your own or in groups?*" using terms in Table 1. Panel (b) categorized answers to the second question in the prompt, "*If you have positive reactions, negative reactions, questions, or concerns, please note them here:*" Students overwhelmingly report positive reactions to the prospect of field trips, but a majority also have concerns about the time and logistics for completing work outside the classroom. Responses are shown in aggregate but were not significantly different over the three terms.

questions in the same order. The instructor tried, to the extent possible, to narrate in person the same information that was provided in the app.

Students who attended field trips in-person were sent a direct link to an anonymous Qualtrics survey when they turned in their labs on paper (supplementary material). Students who chose the self-guided options were prompted to complete the survey before uploading their answers. Students were not prevented from uploading their answers if they chose not to complete the survey, but all students did choose to. Survey responses were compared between the two groups using a 2-tailed test for unequal variance.

Results

Student perception of field trips

The three course sections evaluated here had a total of 70 students enrolled; 67 of these were present for the writing prompt on the first day of class. In response to the first question in the prompt, regarding initial reactions, 75% of students gave a qualitatively positive reaction, using words like 'excited' or 'fun' while 6% used words that were neutral ('seems ok', 'fine with me'), 16% had a mixed reaction expressing both excitement and concern and 3% did not express a clear opinion (Figure 3; Table 1). No student expressed a clearly negative reaction.

In response to the second question in the prompt, asking for questions or concerns, 48% of students indicated concern over the time it would take outside of class, 18% noted concerns about travel off campus and transportation options, 24% mentioned both time and travel and 9% did not express any particular concern. One student noted concern about the impact on grades and another single response indicated concern about the weather. Student initial reaction (first question) was coded separately from concern (second question), thus a single student may have a positive reaction, but also a concern about travel or time. For example, a student responding, "I'm really excited to get outside and it sounds fun, but I'm also not sure how I'll get there alone since I don't have a car" would be coded as having both a 'positive' reaction and a 'concern about travel'.

Student choices and learning outcomes

Of the 70 students in all three course sections, only three students elected to fulfill both field trip requirements in person, while 22 chose 1 in-person and 1 self-guided trip, with the majority of students choosing to do both trips using the app (Table 2). Students who chose at least one instructor -guided option worked fewer hours and had fewer outside care responsibilities than their peers who chose to use only self-guided trips (Figure 4). As reported in the post-trip survey (Supplementary Material), a majority of students in both groups used their own cars (72%) or borrowed cars (2%) for transportation, with 11% asking someone else for a ride and 15% using public transportation. Students were also asked whether or not finding transportation to the site was difficult; 65% of self-guided students and 71% of instructor-led students reported that it was not, while 35% of self-guided and 29% of in-person said it was. Of those who chose to report a reason, all responses mentioned traffic and/or the availability of parking at the site.

The post-trip survey provided five prompts on a Likert-style scale from 1-10 asking the student to rate their interest, enjoyment, and learning from the field experience (Supplementary Material). While lab scores for the two groups were similar (Table 2), students self-reported a slightly higher benefit to the understanding of the material when attending the trip in person (Figure 5). Scores for enjoyment and engagement in the experience were the more similar among the two groups. Students taking self-guided trips also reported slightly higher scores for both enjoyment and looking at their surroundings in a new way. Changes in interest level were also similar, but slightly higher for those students attending with the instructor (Figure 5). None of the differences in survey responses were statistically significant.

In response to an open-ended prompt in the survey 'What was the most enjoyable part of the field trip?' students in both groups tended to note serendipitous observations, "I saw a hawk fishing and it was really cool!"; enjoyment of being outside, "I just really like walking around and being out there"; and the opportunity to connect the course to the local environment, "I just never really saw the city this way before, and it was cool." Responses to

Table 1. Terms used to code for positive, neutral or mixed response as shown in Figure 3.

Responses coded as 'positive'	excited/exciting, good; 'looking forward to'; fun; positive; enriching; beneficial; 'better for my learning'; enjoy/enjoyable; 'great idea'; eager; cool; 'great experience', 'I like the idea'
Responses coded as 'neutral'	Ok; fine; 'I expected it from hearing about the class'; 'I don't mind'
Example responses coded as 'mixed'	'… excited but nervous …'; 'good for learning but I'm anxious about new places'; 'I like the idea but don't really want to do it'

Table 2. Number of students choosing different combinations of trip options. Students were asked to complete any two options during the quarter. Average scores are the average total field lab score for all students in that category.

	Spring 17 (23 students)		Spring 18 (23 students)		Fall 18 (24 students)	
	# students	Average composite score	# students	Average composite score	# students	Average composite score
2 trips in-person	1	97%	2	95%	0	NA
2 trips self-guided	10	89%	6	97%	14	91%
1 of each option	7	90%	8	93%	6	98%
only 1 completed; self-guided	3	85%	1	98%	2	93%
1 self-guided and 1 museum	0	NA	5	96%	0	NA
did not complete	2	0%	1	0%	2	0%

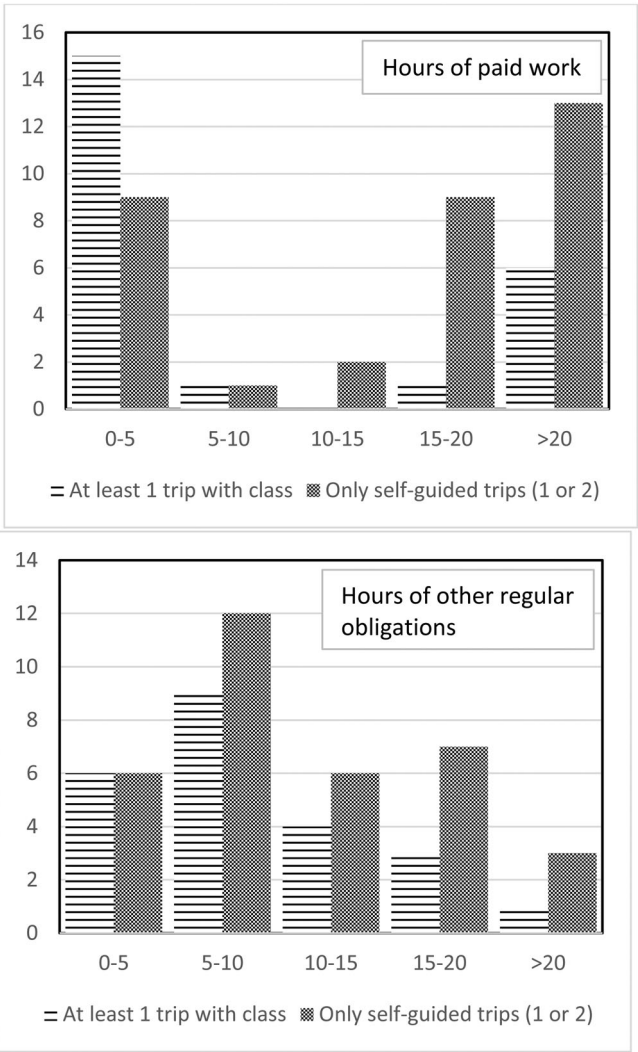

Figure 4. Only three students elected to take both trips with the instructor. Here we compare the reported working hours and other regular obligation (family care, work at family business, unpaid internships, etc). for those students who attended at least one trip with the instructor to those who chose only self-guided options.

the survey prompt asking for the least enjoyable part tended to note external factors like weather, parking, and interactions with non-class participants in the area.

Discussion

Student interest and barriers to participation

The results of the initial writing prompt indicate a high level of interest from students in engaging in field work and having new experiences outside the classroom. That students report such high levels of interest in this kind of activity even with significant concerns over their ability to participate should provide ongoing motivation to make such experiences available across introductory courses. None of the students in these sections were on an enrolled path to an Environmental Science major, but many were pre-major students and may have been open to considering the major as an option. Despite this high interest level across three different sections surveyed, previous course sections never exceeded 50% participation for weekend or evening field trips, with students asking instead for alternative written assignments.

While most students chose to use the app for at least one of the two required trips, there was a notable difference in the reported hours for paid work and outside commitments between those who chose only app-based trips compared to students who chose to attend at least one scheduled trip with the instructor (Figure 4). If field trips are a desirable component of introductory courses, as is suggested by the initial writing prompt (Figure 3), and positive introductory course and field experiences are an important recruiting tool for geoscience majors (Kortz et al., 2020; Stokes et al., 2015), introductory courses across the geosciences should be mindful of who is left out when weekend or evening field trips are used to achieve key learning objectives. This is particularly important if those objectives include larger affective outcomes for increasing affinity for the geosciences.

Student learning outcomes

There are a variety of intended outcomes to field work at different levels, including skill-based outcomes such as mapping or constructing a stratigraphic column, content knowledge about process, or interpretive skills, among others. The results we report here are mainly relevant to more typical introductory-level goals of identifying materials and

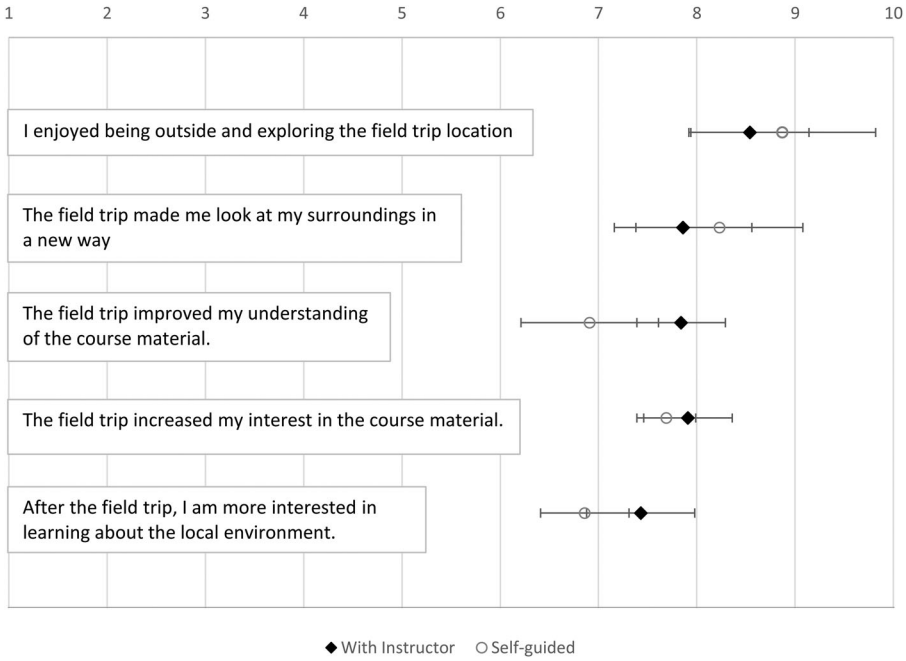

Figure 5. Responses to the survey prompt "On a scale of 1 (least) to 10 (most), move the slider to indicate your agreement with each statement below:" (Supplementary Material). Means and standard deviation are given. The means of the two groups were compared with a 2-tailed test for unequal variance and were not found to be statistically significant ($p = 0.05$) for any of the questions. Each response is included regardless of the combination of trips taken by a specific student; with 70 total students, 140 possible responses are available. With Instructor $n = 27$, Self-guided $n = 62$. Remaining students attended the museum option or did not complete both required trips.

processes in natural settings or simply seeing processes in action. We report, for example, that lab scores did not differ greatly between the groups, but it should be noted that the questions were largely based in naming features or simple observation and did not ask for higher order interpretations of complex features.

Students taking the trip in-person were more somewhat more likely to report feeling that the experience of making these simple observations in the field was helpful to their understanding of the course material, despite the fact that they did not have notably better scores on the field trip labs. Further work with a variety of trips and content questions is needed to better assess actual and perceived learning gains. The self-guided modality may not be applicable, for example, to upper division field trips or those with strongly skill-based learning outcomes. As with all field trips, the content outcomes are best realized when they are reinforced and connected through other activities in lab and classroom. The trips described here are largely of the 'geo-tourism' variety and more could be explored with content outcomes from trips that ask deeper process-oriented questions.

While there are a few patterns of interest in the survey data, none are statistically significant differences. This lack of statistical significance in comparing the two groups is interesting in itself, as it offers preliminary evidence that the two modes are both, on average, offering similar outcomes for students, although individual student perceptions vary. Continued surveys, especially to build a larger sample size for in-person trips, would aid in understanding whether the patterns of interest noted here are meaningful. As sample sizes grow through future studies, it will also become important to compare experiences across different mobile apps as the number of options for mobile geoscience field guides expands.

While specific high-level content gains were not always apparent or perceived, the high level of enjoyment and observation of their local environment is itself a positive outcome and suggests the self-guided students were able to successfully meet the three previously unstated affective learning objectives described above. Students using the app-based field trips in fact reported a slightly higher level of enjoyment in the trips, which may reflect the fact that they were free to choose times and weather conditions, for example, while students attending the instructor-led trip may have felt less free to explore or simply stop and enjoy the location. Additionally, at least two of the instructor-led outings took place in relatively cold and wet weather.

Both groups reported an increased interest in the course material, an outcome we often assume about field experiences that is upheld here. While there were some differences in perceived educational gain (Figure 5) indicating that attending a trip with an instructor may be more beneficial to the stated content learning objectives for field trips, the fact that almost every student went outside and reported enjoyment and positive changes in their overall interest in their surroundings meets the affective objectives in a way that a written research alternative cannot.

Positive affective outcomes of field trips reported in the literature are varied. Reported benefits include aspects of enjoyment and sense of place (van der Hoeven Kraft et al., 2011), which appears to be met and potentially even increased using the flexibility of the self-guided trip (Figure 5). Gains in affective outcomes related to group work including aspects of social belonging, learning field skills through watching a

professional, collaborative problem solving (Mogk & Goodwin, 2012) are not mimicked in the self-guided mode compared to a guided group trip, although there may be potential for developing small group trips or trips led by peer teaching assistants to address these concerns.

The app interface

The Flyover Country app has an intuitive interface and students did not report issues in using the app. Anecdotally, a few students mentioned in passing being 'annoyed' that the app used a lot of their battery or that they had to walk around with their phones out 'looking like tourists' but overall use and interaction with the app were not a significant barrier. The app does work on all platforms for tablets and phones. At UWB students are able to check out tablets from the library if needed, but access to mobile devices may present a barrier at some institutions.

Flyover Country is one of several options an instructor could explore for self-guided field trips. Other geoscience-focused apps, such as Strabo and Rockd, are available with some similar features. Instructors could also choose to develop content in freely available online mapping platforms, or even send students out with paper-based trips, however, these options lack the geo-referencing and embedded content capabilities in the available apps. The best option for students may depend largely on access to devices as well as the importance of integrated geo-location and supplementary information such as geologic base maps or embedded figures.

Limitations and concerns

While the asynchronous self-guided trips remove many of the time barriers present for students, they do not remove, and may even create issues, with transportation to the sites. Sites used here are accessible by public transit, although most students reported driving and some students reported dislike at having to find or pay for parking in some cases. Using sites on or close to campus if possible would be ideal.

Sending students to field locations asynchronously has the potential for liability concerns related to transportation and activities on site. The three trips described here take place on public walkways and/or public parks; two are fully accessible. Students read and signed the standard University field trip waiver of liability used for all course-related group trips on campus. On the liability form they are advised of typical concerns (such as walking on uneven surfaces) and asked to acknowledge that they have been advised to leave the field trip area and talk to the instructor if they observe or encounter unsafe conditions including, but not limited to, unsafe trail or walkway conditions, weather conditions, or unsafe or uncomfortable behavior by others in the area.

Students were responding to questions largely observational in nature and intended to meet the broad learning objectives: (1) *to recognize and describe the complexity and scale of real-world geologic landforms and* (2) *to describe the role of geologic processes in the formation of local environments*. The use of self-guided trips for specific skills development or to train students in careful observation leading to process interpretations needs to be evaluated in more detail to compare against instructor-led trips. Student responses to the post-trip survey indicate general satisfaction with the field trip experience and gains in the affective domain, however, more detailed qualitative surveys, observations, and interviews are needed to better understand the student experience.

Summary

We found that students overwhelmingly express excitement about field trips coupled with concern over time and logistics. Students generally found the Flyover Country app easy to use and were able to answer assessment questions with similar competency to those who attended the same trip in person. Student perception of learning gains was slightly lower for self-guided trips, but affective outcomes were high for both groups. While further questions remain about the efficacy of using a self-guided mode for different levels and types of content, the ability to increase enjoyment and interest for introductory students in a way that meets their needs with flexible scheduling is an important addition to the toolkit for educators at the introductory level, especially at institutions with high numbers of students with barriers to traditional field experiences outside of class time.

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References

Birlenbach, D., Shinneman, A., Loeffler, S., & Myrbo, A. (2019, July). Flyover country: Creating flexible field experiences using a mobile geoscience app. *In the Trenches*, *9*(3), 10–12

Boyle, A., Maguire, S., Martin, A., Milsom, C., Nash, R., Rawlinson, S., Turner, A., Wurthmann, 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

Bursztyn, N., Walker, A., Shelton, B., & Pederson, J. (2017). Assessment of student learning using augmented reality Grand Canyon field trips for mobile smart devices. *Geosphere*, *13*(2), 260–268. https://doi.org/10.1130/GES01404.1

Carabajal, I. G., Marshall, A. M., & Atchison, C. L. (2017). A synthesis of instructional strategies in geoscience education literature that address barriers to inclusion for students with disabilities. *Journal of Geoscience Education*, *65*(4), 531–541. https://doi.org/10.5408/16-211.1

Cliffe, A. D. (2017). A review of the benefits and drawbacks to virtual field guides in today's Geoscience higher education environment.

International Journal of Educational Technology in Higher Education, *14*(1), 1–14. https://doi.org/10.1186/s41239-017-0066

Dolphin, G., Dutchak, A., Karchewski, B., & Cooper, J. (2019). Virtual field experiences in introductory geology: Addressing a capacity problem, but finding a pedagogical one. *Journal of Geoscience Education*, *67*(2), 114–117. https://doi.org/10.1080/10899995.2018.1547034

Elkins, J. T., & Elkins, N. M. L. (2007). Teaching geology in the field: significant geoscience concept gains in entirely field-based introductory geology courses. *Journal of Geoscience Education*, *55*(2), 126–132. https://doi.org/10.5408/1089-9995-55.2.126

Gilley, B., Atchison, C., Feig, A., & Stokes, A. (2015). Impact of inclusive field trips. *Nature Geoscience*, *8*(8), 579–580. https://doi.org/10.1038/ngeo2500

Kirkby, K. C. (2014). Place in the city: Place-based learning in a large urban undergraduate geoscience program. *Journal of Geoscience Education*, *62*(2), 177–186. https://doi.org/10.5408/12-396.1

Klippel, A., Zhao, J., Jackson, K. L., La Femina, P., Stubbs, C., Wetzel, R., Blair, J., Wallgrün, J. O., & Oprean, D. (2019). Transforming Earth science education through immersive experiences: Delivering on a long held promise. *Journal of Educational Computing Research* , *57*(7), 1745–1771. https://doi.org/10.1177/0735633119854025

Kortz, K. M., Cardace, D., & Savage, B. (2020). Affective factors during field research that influence intention to persist in the geosciences. *Journal of Geoscience Education*, *68*(2), 133–151. https://doi.org/10.1080/10899995.2019.1652463

Lenkeit Meezan, K. A. (2012). Virtual field trips for introductory geoscience classes. *The California Geographer*, *52*, 71–88.

McConnell, D. A., & van der Hoeven Kraft, K. J. (2011). Affective domain and student learning in the geosciences. *Journal of Geoscience Education*, *59*(3), 106–110. https://doi.org/10.5408/1.3604828

Mead, C., Buxner, S., Bruce, G., Taylor, W., Semken, S., & Anbar, A. D. (2019). Immersive, interactive virtual field trips promote science learning. *Journal of Geoscience Education*, *67*(2), 112–131. https://doi.org/10.1080/10899995.2019.1565285

Mogk, D. W., & Goodwin, C. (2012). Learning in the field: Synthesis of research on thinking and learning in the geosciences. In: Kastens, K.A., and Manduca, C.A., eds., *Earth and mind II: A synthesis of research on thinking and learning in the geosciences*. Geological Society of America Special Paper. 486, p. 131–163, https://doi.org/10.1130/2012.2486

Myrbo, A., Loeffler, S., Shinneman, A. L. C., & Mcewan, R. (2018). Outreach and educational opportunities created by open-data resources. *Past Global Change Magazine*, *26*(2), 74–72. https://doi.org/10.22498/pages.26.2.74

Petcovic, H. L., Stokes, A., & Caulkins, J. L. (2014). Geoscientists' perceptions of the value of undergraduate field education. *GSA Today*, *24*(7), 4–10. https://doi.org/10.1130/GSATG196A.1

Stokes, P. J., Levine, R., & Flessa, K. W. (2015). Choosing the geoscience major: Important factors, race/ethnicity, and gender. *Journal of Geoscience Education*, *63*(3), 250–263. https://doi.org/10.5408/14-038.1

University of Washington, Bothell (n.d). Retrieved from https://www.uwb.edu/academic-affairs/analysis

van der Hoeven Kraft, K. J., Srogi, L., Husman, J., Semken, S., & Fuhrman, M. (2011). Engaging students to learn through the affective domain: A new framework for teaching in the geosciences. *Journal of Geoscience Education*, *59*(2), 71–84. https://doi.org/10.5408/1.3543934 https://doi.org/10.5408/1.3543934a

Warburton, E. C., Bugarin, R., Nuñez, A.-M., & Carroll, D. C. (2001). *Bridging the gap academic preparation and postsecondary success of first-generation students, NCES 2001-153*, by Edward C. Warburton, Rosio Burgarin, and Anne-Marie Nunez. Project Officer: C. Dennis Carroll.

Whitmeyer, S. J., Mogk, D. W., & Pyle, E. J. (2009). *Field geology education: historical perspectives and modern approaches*. Geological Society of America.

Wilson, C. (Ed.) (2017). *Status of recent geoscience graduates 2017*. American Geosciences Institute.