

Full title: Assessing motivations, benefits, and barriers of implementing virtual field experiences in
geoscience-related disciplines

Running Title: Motivations, benefits, and barriers for virtual field experiences

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ABSTRACT

Outdoor field experiences have long been part of the traditional curriculum in geoscience-related disciplines and are considered a key aspect of professional development in these areas. When the COVID-19 pandemic forced the cancellation of many field excursions around the world, geoscience departments were forced to make abrupt changes to the ways students would be introduced to field study. Virtual field experiences, which were often utilized prior to COVID-19 in a variety of ways, including preparation for in-person fieldwork, increasing student interest, and increasing student accessibility, were developed and employed as alternative options to in-person field experiences. This embedded mixed-methods study used open, hierarchical coding schemes with referential category structure to code open-ended survey responses from 89 department heads and 27 instructors in geoscience-related departments across the U.S. The study was aimed at better understanding acceptance and familiarity with VFEs, motivations for use, and the benefits and barriers encountered during development and implementation. Binary quantitative data was collected to identify institution type, familiarity with, and motivation for the use of VFEs. Opportunities for student diversity, inclusion, and access for students from historically underrepresented groups (BIPOC, disabled students, women, and LGBTQ+ students) were the most immediate benefits recognized. The most often cited barriers were time, skills, and resources needed to create VFEs and put them to use. As VFEs have been utilized in a variety of ways before and during COVID-19, it has become increasingly necessary to discuss the roles they will play going forward in academic and professional geoscience-related spaces.

INTRODUCTION

Outdoor field experiences, including single-day or short overnight trips outside the classroom setting and standalone courses such as geology field camps, have been a part of the required curriculum in geosciences and related disciplines for well over a century. They are considered by many to be a vital part of student success in these subjects (Bacon & Peacock, 2021; Kent et al., 1997; Peace et al., 2021;

Whitmeyer & Mogk, 2009) by directly applying conceptual ideas learned in the classroom to the natural world. In fact, the adage, “The best geologist is the one who has seen the most rocks,” from an address by H. H. Read (1940), has been passed down by geologists for decades, suggesting that success is driven by firsthand experience in the field rather than dissemination of knowledge in the classroom. Past research has substantiated this notion by showing that field excursions may lead to an increase in advanced cognitive skills (Petkovic et al., 2014) such as the ability to think in three dimensions spatially, understand deep geologic time, and solve complex problems (Hannula, 2019; Mogk & Goodwin, 2012), all while helping to prepare students with the scientific and professional skills needed to succeed in the workforce after graduation (Buckley et al., 2022; Streule & Craig, 2016). Previous literature suggests that students participating in field activities may also develop deeper social connections (Fuller et al., 2006; Kempa & Orion, 1996) which may lead to higher overall enjoyment of fieldwork as a learning style (Boyle et al., 2007). Building relationships with instructors and other students can help to promote learning through enculturation (Brown et al., 1989; Fedesco et al., 2020) by allowing students to observe expert behavior in the field and to begin learning the necessary problem-solving skills *in situ* (Mogk & Goodwin, 2012).

With the onset of the global COVID-19 pandemic in March 2020, there was a momentous change in the way people interacted with one another and went about their daily lives. The academic sector was not immune to this shift (García-Morales et al., 2021; Sahu, 2020). Restrictions on gathering in common spaces meant that many classes normally held in person were forced to switch to an online format. As colleges and universities shut down worldwide in response to the crisis, instructors were forced to rethink class organization and instructional methods, including unexpectedly reexamining and implementing online modalities (Agasisti & Soncin, 2021; García-Morales et al., 2021; Pokhrel & Chhetri, 2021; Stukalo & Simakhova, 2020). Because field excursions are so common in, and arguably one of the defining aspects of, geosciences-related disciplines (Bursztyn et al., 2022) these impacts were felt in

unique ways. In addition to changes in class dynamics, class field trips, and scheduled summer field courses were largely canceled, redesigned as self-guided or independent study options, or adapted to include a virtual component (Bacon & Peacock 2021; de Paz-Álvarez et al., 2022; Peace et al., 2021). However, it has not yet been determined how many geoscience-related departments in the U.S. temporarily or permanently altered their field course offerings to virtual field experiences (VFEs).

VFEs are not new learning approaches in the earth sciences and have often been used as supplements to traditional fieldwork (Buckley et al., 2022; Hurst, 1998; Stainfield et al., 2000). They do not offer the same physical experiences as an in-person field trip, especially from a sensory perspective (Çalışkan, 2011; Evelpidou et al., 2021; McCauley, 2017; Stumpf et al., 2008). They have long been considered useful for preparing students for coursework or data collection in the field (Arrowsmith et al., 2005; Falk et al., 1978; Orion & Hofstein, 1994; Shepherd, 1985; Warburton & Higgitt, 1997), increasing efficiency and productivity of field excursions (Senger et al., 2021b; Stainfield et al., 2000), and allowing for post-fieldwork exercises and review (Bentley, 2014; Stainfield et al., 2000; Whitmeyer & Dordevic, 2021).

Aside from these ancillary benefits, VFEs offer a variety of other advantages over their traditional counterparts. Budget constraints leading to reductions in field-based activities (Buckley et al., 2022; Bursztyn et al., 2017; Cho & Clary, 2020; Mullens et al., 2012), weather uncertainties and extreme conditions (Klippel et al., 2020; Senger et al., 2021a), concerns over safety issues (Buckley et al., 2022; Clancy et al., 2014; Giles et al., 2020), large introductory class sizes (Dolphin et al., 2019), and even sudden, widespread disease outbreak (Fuller et al., 2003; Peace et al., 2021) are all examples of barriers that may be wholly or partially overcome by using VFEs. Some students who may have previously been unable to join geoscience programs due to the often-exclusive nature of field study may now have the opportunity to participate through the use of VFEs. Those who may benefit from the implementation of VFEs and the access they provide, while not an exhaustive list, include students with health problems,

physical or mental disabilities (Arrowsmith et al., 2005; Atchison & Martinez-Frias, 2012; John & Khan, 2018), historically underrepresented racial and ethnic communities (Haynes & Jacobson, 2015), and those with family, work, or other personal obligations (Birlenbach, 2019; Ruberto, 2018).

As part of this work, we seek to answer the following research questions:

- i) What is the level of familiarity among department faculty and leadership of virtual field experiences?
- ii) What were some of the motivating factors for implementing VFEs before and during the COVID-19 pandemic?
- iii) What were some noticeable benefits and barriers that were encountered by administrators and instructors while attempting to employ VFEs?

Theoretical Framework

Our research goals for this project are to assess the awareness level of VFEs by geoscience-related departments across the U.S., the primary motivations for implementation, and the ways they are being used as alternatives to in-person field trips and field courses, especially as related to the COVID-19 pandemic. We look at awareness, acceptance, and implementation of VFEs from both departmental and instructor perspectives through the framework of the Technology Acceptance Model (TAM). TAM was first introduced by Davis (1986, 1989) as an adaptation of the Theory of Reasoned Action (Fishbein and Ajzen, 1975) and theorizes that the acceptance of technology is based on two primary factors—perceived usefulness and perceived ease of use—and that these two factors can predict attitudes toward technology and intent to use technology (Masrom, 2007). It has seen additional development and enhancement since its introduction (Venkatesh and Davis, 2000) and has been used across a variety of sectors including tourism (Khalil et al., 2023), online retail (Lui and Forsythe, 2010; ur Rahman et al., 2018), telehealth (Hu et al., 1999), and education (Boese et al., 2009; Inocencio et al., 2022; Masrom, 2007; Villena-Taranilla et al., 2023). Here, we use the perceived usefulness element of the TAM

framework to better understand the primary motivations for VFE implementation, and the perceived ease of use element to understand the benefits and barriers that have been encountered while attempting to employ VFEs.

Positionality

It is important to acknowledge the lead author's identity as an able-bodied, white man in shaping perspectives on in-person fieldwork in geoscience-related disciplines. Having participated in fieldwork in the environmental consulting industry and having served as a teaching assistant for several weekend and summer field trips to geologically noteworthy parts of the U.S. as a geology undergraduate and graduate student, a unique understanding of, and appreciation for, the value and importance of "being there" in geoscience-related field study was developed. These experiences, and the interactions with co-workers and fellow students involved, also brought to light many of the obstacles faced by those who expressed interest in wanting to be part of the geoscience community but felt held back or excluded in some way.

This work was born out of a semester project in a qualitative research methods class attended online by the lead author as a first-year Ph.D. student during the summer of 2020. The uncertainty surrounding the COVID-19 pandemic at the time of the project raised significant questions regarding the future of traditional field excursions and inspired conversations between the authors about the applicability of alternative techniques (i.e., VFEs) as supplements or replacements for traditional field study. Further discussion focused on how VFEs might be utilized beyond the scope of a global pandemic as a resource to increase involvement in the geosciences.

Both authors feel strongly that traditional, in-person field experiences are important to the education and success of students in geoscience-related fields, but that VFEs are a valuable tool that may be used to help ease logistical or financial challenges related to in-person fieldwork, increase

interest and participation in these disciplines through the development of a more inclusive community, and continue to support the growth of the geosciences workforce.

METHODS

This embedded mixed-methods study includes quantitative and qualitative data collected simultaneously from our participants using binary survey and open-ended questions (Bastable et al., 2019; Creswell & Clark, 2010; Edmonds & Kennedy, 2017). We prioritized qualitative data with an emphasis on analysis of personal text from open-ended survey questions but still collected both datasets from our participants.

We realize there is often some overlap among department administration and field faculty. Our goal for this project was to better understand the experiences of using VFEs by department heads from a more generalized, department-level perspective, and more specifically by those faculty who are directly involved in the instruction of class field trips and field courses, especially in response to the sudden and monumental “disruption” brought on by COVID-19 (García-Morales et al., 2021). Additionally, because many departments do not offer traditional geology field camps or other related standalone field courses but do include course-specific field trips in their curriculum, we felt it was necessary to provide separate questions regarding these modalities to allow for a greater variety of responses. Because there is no existing theory for how faculty and department leadership might respond to the impacts of a global pandemic, we utilized the embedded mixed methods approach to holistically explore the phenomenon of how this population made instructional decisions regarding VFEs during a global pandemic and the perceived benefits and barriers of VFEs.

Creation of Mailing List

The American Geoscience Institute’s (AGI) Directory of Geoscience Departments (Wilson, 2019) and The University of South Dakota’s Geoscience Departments WWW Directory of U.S. and Canada (Ansfield & Heaton, 2017) were used to create a list of heads of 1,015 geoscience-related departments

at 2- and 4-year colleges and universities across the United States that included names, email addresses, and department names. The list was then used as the basis for the dissemination of the surveys described below.

Two surveys were created, one aimed at department heads and lead decision-makers of geoscience-related curriculum (hereafter referred to as *department heads*), and one targeting instructors of geoscience-related curriculum that included field trips either as part of the class structure or who were involved in the instruction of field-based courses, including geology field camps. Both surveys were reviewed for content, question phrasing, spelling, and grammar by members of the Geocognition Lab at Auburn University prior to distribution. The Auburn Geocognition Lab is led by Dr. Karen McNeal (co-author), a subject matter expert in the field of geoscience education research, and is made up of six doctoral students, including the lead author. The instructor-focused survey was reviewed by two members of the Auburn University Department of Geosciences faculty who had recently instructed the department's field camp. Unfortunately, multiple requests outside the Geocognition Lab group for review of the department head-focused survey went unanswered. Comments and revisions made for each survey were largely grammatical. One question was added to each survey regarding respondents' institutional status as a Minority Serving Institution (MSI) or Historically Black College or University (HBCU). Each survey is available by contacting the corresponding author.

Recruitment

Approval was received by Auburn University's Institutional Review Board (Protocol #22-117 EX 2203). Respondent demographic data was not collected as part of either survey. No incentives were offered or provided for participation in either survey.

The first 27-question survey was sent to the list of 1,015 department heads via email using Qualtrics cloud-based software. The survey included questions regarding the effects of the COVID-19 pandemic on class field trips and field courses, the use of VFEs as a supplement to, or replacement for,

field trips and field courses in the past and in the future, benefits, and barriers to using VFEs, and any benefits specifically related to diversity, equity, and inclusion (DEI). The survey contained 11 'yes-or-no' questions and 16 short-answer or open-ended questions. Additionally, this initial survey asked for names and email addresses of instructors in those departments who include field trips as part of class curriculum, and/or those who are instructors of field courses.

After receiving the results of this department head survey, a second 26-question survey was sent, also using Qualtrics cloud-based software, to 193 instructors who were identified in responses to the department head survey. Department heads were asked to provide names and contact information of instructors in their department who included field trips as part of class curriculum or were instructors of field courses. These questions were similar to those in the initial survey sent to department heads, but some questions more specifically differentiated between class field trips and field courses. This survey contained 7 'yes-or-no' questions and 19 short answer or open-ended questions.

Data Cleaning

Of the 1,015 survey requests sent to department heads and lead curriculum decision-makers, a total of 98 responses were received. The responses were downloaded from Qualtrics into a Microsoft Excel file and the data were cleaned to remove any potential identifying information. Of these, 89 (8.8% of the total distributed) were over 30% complete and included useful responses for analysis. Those that were not included in the analysis were below 5% complete and no survey information was gathered. The remaining respondents did not consent to participate in the survey.

A total of 29 responses were received from the survey to instructors of class field trips and field courses. The responses were downloaded from Qualtrics into a Microsoft Excel file and the data were cleaned to remove any potential identifying information. Of the total responses, 27 were over 40% complete (14% of the total 193 distributed) and included useful responses for analysis. The remaining two responses were below 5% complete and no survey information was gathered.

Quantitative Data Analysis

We used Microsoft Excel to calculate the percentage of responses from 2- and 4-year institutions, as well as those that were considered MSIs or HBCUs. Excel was also used to quantify percentages of answers to several 'yes' or 'no' questions.

Qualitative Data Analysis

Open-ended responses were copied by the lead author to a Microsoft Word document and uploaded to Delve, a cloud-based coding software, to begin initial qualitative analysis using a thematic analysis structure with open, hierarchical coding schemes using a referential category structure as described by Richards and Richards (1995). The initial round of coding used a combination of deductive and inductive approaches (Proudfoot, 2022), each as described by Bingham & Witkowsky (2022) and Burnard et al. (2008). Responses were first grouped into specific categories based on the main topic of the survey question (a deductive, or top-down approach), then additional codes were created based on response excerpts (an inductive, or bottom-up approach). Following this initial coding step, the responses were uploaded to the web-based coding software Dedoose for additional code refinement and inter-rater analysis. Excerpts were largely coded into single categories; however, some response excerpts could fit into more than one code category. For example, the department head survey comment *"The idea is to be able to offer a greater number of field experiences in a more standardized way"* falls under both ***Student Experience/Opportunity*** and ***Inclusion/Accessibility*** categories, while the instructor survey comment *"Didn't have to manage physical abilities or weather issues which meant students could focus on the content instead of just surviving"* falls under both ***Student Skills/Success/Professional Development*** and ***Inclusion/Accessibility*** categories. A total of 63 codes were created from the 89 department head respondents and a total of 74 codes were created from the 27 instructor respondents. Once coding was completed, co-coding was completed using approximately 15% of excerpts from each question category (McNeal et al., 2014; Park 2005) to establish interrater

reliability (further details in Co-Coding and Inter-rater Reliability section). The external coder was a doctoral student in the Auburn Geocognition Lab who had completed coursework in qualitative research and analysis. Example excerpts and codes from each survey may be viewed in the supplemental material.

Co-Coding and Inter-rater Reliability

One round of co-coding was completed for each survey using approximately 15% of the total excerpts from each question section (McNeal et al, 2014; Park, 2005). This resulted in a pooled Cohen's kappa score of 0.80 for the department head survey (individual code scores ranged from 0.43 to 0.97) and a pooled Cohen's kappa score of 0.66 for the instructor survey (individual code scores ranged from 0.19 to 0.88). The pooled kappa value for each survey represents substantial strength of agreement between codings (Landis & Koch, 1977).

RESULTS

Data collected from each survey was meant to determine the awareness level of VFEs by leadership and faculty in geoscience-related departments across the U.S., to understand if and how VFEs are being used as alternatives to in-person class field trips and field courses, and to recognize the barriers and benefits faced when developing and employing VFEs.

Of the 89 responses to the department head survey used in this study, approximately 73% came from 4-year institutions and 27% from 2-year institutions. Of these, 31.5% are considered MSIs or HBCUs. This can be broken down more specifically with 18.5% of 4-year institutions being considered MSIs or HBCUs, while roughly 66.7% of the responding 2-year institutions fall into this category. Additional analysis of responses to yes/no questions in this survey may be seen in Table 1.

Table 1. Binary results from the survey of department heads regarding institution classification, field-related curriculum requirements and offerings, as well as familiarity with, benefits of, and past or future use of VFEs.

	Survey Responses (%)	
	2-year	4-year
2-Year and 4-year Institutions		
Is your institution primarily a 2-year or 4-year college or university?	27.0	73.0
Yes/No Survey Questions	Yes	No
Is your institution considered a Minority Serving Institution or a Historically Black College or University?	31.5	68.5
Do classes in your department include in-person, field-based excursions as part of the curriculum?	94.4	5.6
Does your undergraduate curriculum require a field camp or other field-based course?	32.6	67.4
Does your department offer an in-person field course or field camp?	34.2	65.8
Are you familiar with VFEs (field excursions taught using digital or virtual programs)?	80.2	19.8
Have there been attempts made in your department to use VFEs in the past?	73.9	26.1
Was professional development credit offered for developing or training to use VFEs?	8.3	91.7
Was professional development credit a motivating factor for VFE development or training?	50.0	50.0
Were there any recognized benefits of using VFEs that were related to diversity, equity, & inclusion of students?	52.1	47.9
Are there plans by faculty in your department to further investigate or use VFEs in the future?	59.0	41.0

Table 2. Binary results from the survey of instructors regarding institution classification, field-related curriculum requirements and offerings, as well as familiarity with, benefits of, and past or future use of VFEs.

	Survey Responses (%)	
	2-year	4-year
2-Year and 4-Year Institutions		
Is your institution primarily a 2-year or 4-year college or university?	22.2	77.8
Yes/No Survey Questions	Yes	No
Is your institution considered a Minority Serving Institution or a Historically Black College or University?	29.6	70.4
Are you familiar with VFEs (field excursions taught using digital or virtual programs)?	96.3	3.7
Have you attempted to use VFEs in the past as part of a class curriculum?	65.4	34.6
Were there any recognized benefits of using VFEs that were related to diversity, equity, and inclusion of students?	50.0	50.0
Do you plan to further investigate or use VFEs for class field trips in the future?	76.9	23.1
Do you plan to further investigate or use VFEs for field courses in the future?	26.9	73.1

Nearly 81% of the responses to the instructor survey came from those at 4-year institutions, with just over 19% from 2-year institutions. A total of 26.9% are considered MSIs or HBCUs. This can be broken down more specifically with three 4-year institutions being considered MSIs or HBCUs (14.3%), while 4 out of 5 (80%) of the responding 2-year institutions fall into this category. Additional analysis of responses to yes/no questions in this survey may be seen in Table 2.

Open-ended questions from each survey comprised individual, broad-level themes with more specific codes given to excerpts within question responses. Responses were first grouped into specific, predetermined categories based on the main topic of the survey question, then additional codes were created within those categories based on response excerpts.

Overall, the coded response excerpts between the two groups were not noticeably different. The most notable difference between the respondent groups was in the length of their responses. While many of the department head responses included short sentences or brief comments, several of the instructors offered more lengthy opinions for some of the open-ended questions, especially regarding why they would or would not use VFEs in the future (department head average = 27.2 words, instructor average = 50.6 words).

Department Heads

COVID-related modifications to field trips and field courses largely included cancellations and/or the use of some remote or virtual options. Those who continued to run field excursions implemented shorter, more localized field trips, and employed COVID-19 safety protocols such as masking, social distancing, and enhanced cleaning practices. COVID-related restrictions and shutdowns were the most frequently mentioned motivations for using VFEs followed by opportunities to provide a universal student experience and increase inclusion and accessibility.

The advantages of VFE use identified in this study varied across individual responses, but student inclusion and accessibility was the most common benefit listed. This was followed by student

engagement and performance, and the ability to “visit” geologically interesting regions of the world that may have previously been difficult to access.

Aside from the perceived inadequacy of VFEs as substitutes for in-person field excursions, lack of access to materials, software, and technology, as well as a perceived lack of time and skills necessary for VFE development appear to be the most glaring obstacle to future VFE employment. These issues, along with a preference for in-person fieldwork, were also mentioned as reasons why respondents were unlikely to employ VFEs in the future.

Instructors

Like the survey of department heads, those who responded to the instructor-focused survey cited cancellation and postponement of fieldwork and the use of remote or virtual options as the most common modification made to field courses and class field trips, followed by the implementation of COVID safety protocols.

COVID-related restrictions and shutdowns were among the most common motivations for using VFEs, with inclusion and accessibility, student success and professional development, financial considerations, and access to new and distant locales were also prominent motivations. Inclusion and accessibility and student success were also mentioned most often as benefits for both field courses and class trips.

Noted barriers to successful VFE implementation in the survey of instructors were similar to those listed in the department heads survey. A lack of access to proper materials and technology along with a need for additional faculty time and skills were mentioned as obstacles to be addressed for consideration of future VFE use.

Codes and subcodes, plus the number of mentions for each category are available in Figure 1 for department heads and in Figure 2 for instructors. Example response excerpts are available as supplemental material.

COVID Modifications - 126

5	Few to None/N.A.
50	Field Trips/Courses Cancelled/Postponed
3	Independent Field Study
3	Instructional/Academic Changes
18	Masks/Distancing/Other COVID Requirements
40	Remote/VFEs/Other Option Developed/Used
7	Shorter/Localized Trips

VFE Motivations - 70

2	Meeting Academic Requirements
4	Access to New/Distant Places
26	COVID Restrictions/Shutdowns
1	Environmental Factors (e.g., weather)
1	Funding/Financial Factors
10	Inclusion/Accessibility
13	Student Experience/Opportunity
6	Student Skills/Success/Professional Development
4	Supplementary to Field Work
3	Transportation/Logistics

DEI-Related Outcomes - 42

9	Allows for Broader Participation
7	Family/Work/Other Previous Obligation
5	Health Issues/COVID
3	Income/Cost/Expense
5	Marginalized/Underrepresented/Cultural
10	Physical Disability/Mobility
3	Universal Student Experience

VFE Barriers - 60

12	Faculty Time/Skills
3	Funding/Administrative Support
16	Materials/Software/Technology
2	Scheduling/Faculty Support
8	Student Engagement/Performance
12	Not a Good Substitute
7	Few to None Encountered/N.A.

VFE Benefits - 72

12	Access to New/Distant Places
2	Better than Nothing
2	COVID Restrictions/Shutdowns
2	Environmental Factors (e.g., weather, poor air quality)
21	Inclusion/Accessibility
1	Materials/Software/Technology
13	Student Engagement/Performance
6	Student Skills/Success/Professional Development
5	Supplementary to Field Work
1	Time/Resource Flexibility
6	Transportation Costs/Logistics
1	Few to None/N.A.

Future Use: Yes - 69

7	Access to New/Distant Places
2	COVID Restrictions/Shutdowns
17	Currently In Use/In Development
2	Environmental Factors
12	Inclusion/Accessibility
3	Resources/Costs
5	Student Engagement/Performance
12	Supplementary to Field Work
9	Worth Attempting for Various Reasons (e.g., "depends on circumstances")

Future Use: No - 42

5	Faculty Time/Skills
10	In-Person Is Preferred
8	Lack of Administrative/Faculty Support
18	Not a Good Substitute
1	Lack of Student Interest/Enrollment

Future Use: Undecided/Unsure - 2**Future Needs - 61**

16	Faculty Time/Skills
6	Funding/Administrative Support
1	Inclusion/Accessibility (e.g., lower student cost)
31	Materials/Software/Technology
7	None/Not Sure/N.A.

Figure 1. deductive coding themes with inductive subcodes and the number of excerpts included from the survey of department heads (n=89).

COVID Modifications - 38

- 1 Official COVID Safety Plan Required
- 14 Field Trips/Courses Cancelled/Postponed
- 1 Independent Field Study
- 5 Masks/Distancing/Other COVID Requirements
- 14 Remote/VFEs/Other Option Developed/Used
- 2 Shorter/Localized Trips
- 1 Few to None/N.A.

Class Trip Motivations for VFE Use - 22

- 4 Access to New/Distant Places
- 1 Better Than Nothing
- 4 COVID Restrictions/Shutdowns
- 4 Inclusion/Accessibility
- 4 Student Skills/Success/Professional Development
- 4 Transportation Cost/Logistics
- 1 Did Not Use/N.A.

Field Course Motivations for VFE Use - 27

- 1 Better Than Nothing
- 6 COVID Restrictions/Shutdowns
- 2 Inclusion/Accessibility
- 1 Student Skills/Success/Professional Development
- 17 Did Not Use/N.A.

Class Trip VFE Benefits - 21

- 3 Access to New/Distant Places
- 4 Inclusion/Accessibility
- 3 Offered Mixed Instructional Methods
- 3 Student Skills/Success/Professional Development
- 2 Supplementary to Field Work
- 2 Transportation Cost/Logistics
- 4 Few to None/N.A.

Field Course VFE Benefits - 23

- 1 Access to New/Distant Places
- 1 Course Completion
- 7 Inclusion/Accessibility
- 5 Student Skills/Success/Professional Development
- 1 Supplementary to Field Work
- 1 Transportation Cost/Logistics
- 7 Few to None/N.A.

DEI-Related Outcomes - 15

- 3 Allows for Broader Participation
- 2 Family/Work/Other Previous Obligation
- 2 Health Issues/COVID
- 2 Income/Cost/Expense
- 1 Marginalized/Underrepresented/Cultural
- 2 Physical Disability/Mobility
- 3 Universal Student Experience

Class Trip VFE Barriers - 27

- 2 Faculty Time/Skills
- 1 Inclusion/Accessibility (e.g., closed captioning)
- 5 Materials/Software/Technology
- 8 Not a Good Substitute
- 6 Student Engagement/Performance
- 4 Student Skills/Success/Professional Development
- 1 Few to None/N.A.

Field Course VFE Barriers - 25

- 5 Faculty Time/Skills
- 1 Inclusion/Accessibility (e.g., closed captioning)
- 2 Materials/Software/Technology
- 4 Not a Good Substitute
- 1 Student Engagement/Performance
- 6 Student Skills/Success/Professional Development
- 6 Few to None/N.A.

Future Needs - 33

- 8 Faculty Time/Skills
- 4 Funding/Administrative Support
- 1 Inclusion/Accessibility (e.g., closed captioning)
- 16 Materials/Software/Technology
- 2 Student Interest/Enrollment
- 2 None/Not Sure/N.A.

Future Use: Yes - 30

- 2 Access to New/Distant Places
- 1 COVID Restrictions/Shutdowns
- 6 Currently In Use/In Development
- 1 Student Skills/Success/Professional Development
- 8 Inclusion/Accessibility
- 2 Resources/Costs
- 1 Student Engagement/Performance
- 5 Supplementary to Field Work
- 4 Worth Attempting for Various Reasons (e.g., "depends on circumstances")

Future Use: No - 19

- 4 Faculty Time/Skills
- 5 In-Person Is Preferred
- 4 Resources/Costs
- 4 Not a Good Substitute
- 2 Lack of Student Interest/Enrollment

Figure 2. deductive coding themes with inductive subcodes and the number of excerpts included from the survey of instructors (n=27).

DISCUSSION

VFEs have seen an increase in popularity over the past several years (Buckley et al., 2022; Dolphin et al., 2019), and our results indicate significant familiarity with, and acceptance of, VFEs among both survey groups as resources that may be useful as supplements or replacements for in-person field excursions going forward. While the most common motivations noted for VFE use in this study were tied to the onset of the COVID-19 pandemic and its timing and uncertain nature, especially during the first few months, several respondents had already taken note of the advantages and benefits VFEs offered as compared to in-person field experiences. Many of these were related to student inclusion and academic success, but finances and logistics were also prominently noted. At the same time, our respondents mentioned several drawbacks and barriers to using VFEs that had been encountered while attempting to develop or use existing programs. These most often included the quality of the student learning experience and the availability of time and resources. Broader acceptance of VFEs in the future will likely be tied to overcoming the barriers noted here, as well as others that were not mentioned in response to our surveys.

Motivations

While many noted the inability of VFEs to provide the same depth of knowledge and experience as in-person field trips, cancellation of these outings in the wake of COVID-19 and the need to fill the resulting instructional gap were the reasons most often given as motivating factors in the development and use of VFEs. Due to the timing and uncertain nature of the early stages of the pandemic, geosciences and related departments were forced to quickly make decisions regarding the future of field outings. Many of those surveyed as part of this work opted to cancel or postpone all field study, shorten the travel time and distance of field excursions, implement COVID safety precautions (i.e., masks and distancing), or employ virtual alternatives.

The use of digital or virtual technologies is not new in the field of education, but the COVID-19 pandemic forced the rapid, widespread adoption of tools such as video conferencing and online examinations, as well as a reassessment of instructional methodologies to match the shift in pedagogical framework (García-Morales et al., 2021; Gerard et al., 2022; Jensen, 2019). VFEs are just one part of the technological wave that swept across the worldwide educational landscape as a result of COVID-19, but one that may be somewhat unique to the geosciences and related fields. Many of these departments rely on field experiences in courses and/or as standalone capstone experiences. These activities require travel and often close in-person contact which can make implementation of pandemic safety precautions difficult, and as such, were greatly impacted by the pandemic.

Motivations mentioned for VFE use that were unrelated to COVID-19 included increasing inclusion and access for students who may have felt excluded or unable to participate previously, and offering the ability to explore areas of the world that can be difficult to access due to time, money, or logistics.

Benefits

The benefits of VFE use can be recognized from a variety of perspectives and are well-documented in previous literature (Arrowsmith, 2005; Buckley et al., 2022; Peace et al., 2021; Klippel et al., 2020; Stainfield et al., 2000). One such documented benefit of VFEs includes being able to prepare students for a later in-person field trip (Senger et al., 2021b). Our work showed that preparation for field outings was a perceived benefit, but our results also showed that student skill development, such as experience with remote sensing and other geospatial data, as well as increased student engagement and participation, were also commonly mentioned benefits to employment of VFEs.

The benefits most frequently noted, however, were related to diversity, equity, inclusion, and accessibility. Many survey respondents saw the added benefit of being able to include students from a wider array of backgrounds who may have previously felt excluded from participation in outdoor field

excursions or geoscience-related programs in general. Overall, in the U.S., scientific disciplines have been less than representative of the nation's population in terms of diversity of race, gender (Beede et al., 2011; Huntoon et al., 2015; National Center for Science and Engineering Statistics, 2021), and disability status (National Center for Science and Engineering Statistics, 2019), and the geosciences are even further behind (Huntoon et al., 2015; Sidder, 2017). Students from historically underrepresented communities (e.g., BIPOC, women, LGBTQ+, disabled students) may feel uncomfortable or unsafe and may face challenges participating in traditional field activities (Atchison & Martinez-Frias, 2012; Clancy et al., 2014; John & Khan, 2018; Pickrell, 2020). Inclusion of these students who might otherwise be interested in pursuing a geoscience-related education, if not for the exclusive nature of field study, may be an important reason for departments to invest time and resources into VFE development (Birlenbach, 2019; Dolphin et al., 2019; Haynes & Jacobson, 2015).

Barriers

While the benefits of using VFEs seem to be clear to department faculty and leadership, obstacles to their sustained use still remain. When asked about the barriers to implementation and what would be needed to make VFEs a more attractive option in the future, aside from not being an acceptable substitute for in-person fieldwork, respondents cited lack of access to proper materials and technology (e.g., audio/visual equipment, software) along with time and skills (e.g., website development, adoption of new technology) needed to successfully develop VFEs that meet their own instructional goals as primary reasons why they have not, and are unlikely to use these programs in the future. Development of VFEs is no small task (Rotzien et al., 2021; Stott et al., 2009), requiring a great deal of planning and data collection (Fleming, 2022; Pugsley et al., 2022). It is evident from responses to these surveys that if VFEs are to become more widely accepted by faculty in geoscience-related fields, even in a supplementary role, future administrative support in the form of time and training will be a key factor (Ramasundaram et al., 2005).

Limitations

Some limitations exist in both the survey design and distribution. More specific respondent demographic data, such as faculty rank and length of tenure, which may have been useful in comparing quantitative data with qualitative responses were not collected. Additionally, both surveys received lower-than-expected response rates (8.8% from the survey of department heads; 14% from the survey of instructors) which may adversely affect the applicability of the results of the study to the larger geoscience community. A variety of factors may have played a role in the low rate of survey responses, including the corresponding author being an unknown identity to many email recipients. A 2016 survey by the National Association of Geoscience Teachers (NAGT), a well-known entity within the geoscience community, sent to U.S. geoscience faculty members achieved a response rate between 24% and 27.3%, depending on necessary exclusions (Egger et al., 2019; Beane et al., 2019). Some recipients of the department head survey may have forwarded it on to faculty members in their departments not understanding that there would be a follow-up instructor survey or dismissed the instructor-focused follow-up survey as a repeat instead of a separate survey for the instructors. The timing of distribution for each survey may have played a role in the lowered number of responses and may be reflected in the results. This was especially noticeable in the circulation of the instructor-focused survey and its release near the end of the Spring 2022 semester and the beginning of the summer field season for many institutions in the U.S., especially 4-year institutions, where instructors may have been unable to respond due to their teaching in remote field locations.

A brief mention should be made of the possibility that respondents' answers to an open-ended question about DEI-related benefits may have been influenced by an earlier binary question asking whether a benefit had been realized as part of VFE use. However, because at least 50% of both groups indicated a noticeable benefit, we believe this shows that it was an important factor in the use of VFEs.

IMPLICATIONS

Traditional field outings and VFEs, while each having its own set of advantages and disadvantages, should not be considered mutually exclusive from one another. Both virtual and in-person modalities share common goals and benefits including learning to enjoy and appreciate the scientific process and all its complexities, development and enhancement of reasoning skills, and learning to work within a team (Dolphin et al., 2019; National Research Council, 2006; Streule and Craig, 2016). The rapid, COVID-driven shift to online instruction has exposed many of the advantages, opportunities, and challenges of online learning (Abu Talib et al., 2021; Garcia-Morales, 2021), similar to those mentioned in these survey responses for VFEs. Digital and virtual tools, including VFEs, have been pushed to the forefront of discussions regarding the use of technology in education and appear set to remain an important aspect of geoscience-related field education, especially as technology continues to evolve (Cliffe, 2017) and bring the field into the classroom.

Looking beyond academia and to employment after graduation, increased participation in geoscience-related departments has the potential to lead to workforce growth in these disciplines and to increased representation in the workforce (Bennett & Lamb, 2016). The U.S. Bureau of Labor Statistics (2021) projects a total national employment growth rate of 7.7% from 2020-2030, including growth related to recovery from the COVID-19 pandemic (approximately 6%). Growth in the geosciences and many (though not all) related fields is expected to roughly match the total projection (Bureau of Labor Statistics, 2022). If the demand in these employment fields continues as projected, there will be opportunities to include groups that are historically underrepresented in geoscience-related fields and promote their perspectives in the workforce (Locke, 2005).

Though virtual field tools have been slowly gaining acceptance in geoscience-related fields and other similar fields, it took the rapid onset of a global pandemic to bring them solidly into the conversation. Our aim in exploring this phenomenon with department chairs and instructors is to provide a starting point for discussions about how and why future resources, professional development,

and classroom implementation may or may not be needed for future consideration of VFEs as an optional tool.

Recommendations and Considerations

Decisions to make use of VFEs should be made with the curricular objectives of individual degree programs in mind, and the role that field outings play in meeting those objectives. Should departmental goals align with many of the stated benefits that VFEs offer, the adoption of VFEs as pedagogical tools, along with a commitment to include time for instructors to devote to the development of the programs and associated modules may be worthwhile.

An additional matter that was not mentioned by survey respondents, but should be considered, is the ability of students to meet the requirements for licensure as professional geologists, which may include a requisite amount of field-based coursework. The National Association of State Boards of Geology (ASBOG) oversees the standardization of testing for its member states in the U.S., however, individual state boards are responsible for setting requirements that applicants must meet to be considered for licensure (ASBOG, 2021). ASBOG representatives reached out to the authors to discuss this matter and noted that some member states had specifically decided against the acceptance of virtual field courses as a satisfactory fulfillment of their standards (J. Patton & D. Sneyd, personal communication, May 26, 2022). Departments may need to consider these constraints if their goal is to graduate geologists who qualify for licensure. However, some departments may determine that the job sectors that their graduates target may not require licensure, and thus, virtual field experiences are acceptable. Once again, we recommend that each department carefully weighs its desired curriculum and aligns student learning outcomes with the affordances and disadvantages of VFEs as they make decisions about their use.

Future Work

Questions remain that can provide opportunities for future study on this topic within the geoscience education community. Follow-up specific to this work may include: i) uncovering whether the amount of time and resources afforded to faculty for the development of virtual field courses have changed post-pandemic; ii) whether VFE development has significantly increased or decreased with the relaxation of COVID-19 protocols and restrictions; and iii) whether learning environments have returned to 'business as usual' with no additional consideration given to the use of VFEs as supplementary or replacement tools for in-person class field trips or field courses.

Opportunities exist for further exploration of a hybrid model that allows students to: i) choose whether to participate through traditional field outings or through VFEs (Indiana University, 2023), ii) participate in a simultaneous hybrid model where some students are in the field, others are in the virtual environment, and they are able to interact with one another (a model for this exists at the GeoSPACE Geoscience Field Program at the University of Florida (Marshall et al., 2022)), or iii) be exposed in an intentional sequence first to the virtual environment where scaffolding to develop skills is emphasized and then followed by an in-person field experience (Rotzien et al., 2021; Schlosser et al., 2022). In this case, the VFE was also utilized as a way for students to continue their learning if they needed to be removed from the field environment due to COVID exposure or diagnosis.

There is also room to examine the effect VFEs have had from a student-centered perspective. To offer examples: investigating how participation in these programs impacted students' interest, engagement, or retention in the geosciences and related fields, and the effects VFEs might have had on student achievement as compared to traditional fieldwork in light of COVID-19. It is also important to consider the social implications of taking students out of the field and putting them in front of a computer. Streule and Craig (2016) discussed the importance of students developing the ability to communicate and collaborate with peers during in-person fieldwork, and consideration should be given to the effects VFEs have on the development of those and other social skills.

Finally, after a brief conversation with ASBOG representatives regarding limitations to obtaining professional licensure, we believe the expansion of this topic to include industry professionals and their perceptions of VFEs are of great interest to the entire geoscience community. Collaboration between members of the geoscience-focused private and academic sectors may lay the foundation for more widescale acceptance of VFEs as alternatives to traditional field courses and open the door for additional discussion surrounding licensure requirements in the future.

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The authors report there are no competing interests to declare.

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TABLES (Supplementary Material)

Supplementary Table 1. *Representative responses and example excerpts from the survey of department heads.*

COVID MODIFICATIONS (126)		
<i>Instructional/Academic Changes (3)</i>		"In 2020, the summer field camp requirement was waived for our geology majors."
		"Suspend requirements, allow substitutions."
<i>Field Trips Cancelled/Postponed (50)</i>		"During the period of lockdown all the field trips were canceled. The summer field camp was canceled in 2020."
<i>Independent Field Study (3)</i>		"Students were encouraged, but not required, to do local travel on their own to sites relevant to the course material."
<i>Few to None/NA (5)</i>		
<i>Masks/Distancing/Other COVID-19 Requirements (18)</i>		"We required students to drive themselves, wear masks and social distancing."
		"Masking and extra vehicles for spacing out students in 2021."
<i>Developed or Used Remote/VFEs/Other (40)</i>		"Made virtual field trips (60-80 minutes) for Physical Geology. For the two semesters we didn't run in-person labs, I developed virtual field labs for Hydrogeology and Geoscience field trip courses."
<i>Shorter/Localized Trips (7)</i>		"Some were run to locations closer to campus to students did not require transportation."
VFE MOTIVATIONS (70)		
<i>Inclusion/Accessibility (10)</i>		"They were initially developed to make the trip experience accessible to all, including those with mobility issues."
<i>Access to New/Distant Places (4)</i>		"Getting to locations where we could not take students."
		"Some places are too far away to visit so we can show certain landscape processes through the virtual field trip."
<i>COVID Restrictions/Shutdowns (26)</i>		"State law prevented in-person trips for two years."
<i>Environmental Factors (1)</i>		"Weather"
<i>Funding/Financial (1)</i>		"Cost"
<i>Academic Requirements (2)</i>		"To provide options for students so that they could continue to move forward through their programs and graduate in a timely fashion."
<i>Student Experience/Opportunity (13)</i>		"Experiential learning opportunity."
		"To provide our students as close to a 'normal' geology field experience as possible during the pandemic."
<i>Student Skills/Success/Professional Development (6)</i>		"...the VFTs do a great job in engaging students and teaching them about the techniques, strategies, and thought processes of geologists (as well as content), so we've kept using them."
<i>Supplementary to Field Work (4)</i>		"We have continued to use these virtual data sets for in-person field classes as supplementary data for mapping and cross section exercises."
<i>Transportation Costs/Logistics (3)</i>		"Our college doesn't have vehicles and it's painstaking to try and go through rental companies."
		"Distance, expense."

VFE BARRIERS (60)

Materials/Software/Technology (16)

"Students don't have access to fast computers and Google Earth crashed."

Few to None/NA (7)

"Student personal computer capabilities was the biggest. Plus, availability and diversity of virtual field trips. Would love a central clearing house of resources."

Funding/Administration Support (3)

"No difficulties. My colleague developed the guide and answer form for the Grand Canyon VFT."

Faculty Time/Skills (12)

"Our main problem continues to be access to the field in terms of vehicles; this is not just because of COVID but reflects lack of prioritization for field-based learning on the part of our 'Fleet Services.'"

Not a Good Substitute (12)

"Finding the time to translate them to an assignment that is workable for students."

"I do not think that virtual experiences can replace in-person experiences in Geology."

"They are a far cry from actually being out in the field."

Scheduling/Faculty Support (2)

"Difficulty scheduling times and class size to meet student schedules."

Student Engagement/Performance (8)

"Disinterest from some students, challenging to assess knowledge gained."

VFE BENEFITS (72)

Materials/Software Technology (1)

"...they are awesome. Berkley has access to collections that I cannot replicate at my institution. ASU has resources and staff to construct incredible experiences that are automatically assessable and difficult to cheat on."

Better Than Nothing (2)

"It was not ideal, but it was something instead of doing nothing."

COVID Restrictions/Shutdowns (2)

"Way to get students to experience the field during COVID."

"...the advantages are for times of crisis in which in-person experiences are not possible."

Environmental Factors (2)

"Ability for students to attend field trips in all weather."

Few to None/NA (1)

Inclusion/Accessibility (21)

"We have been able to offer mapping and other exercises using real data in a geospatial context to students who were physically unable to walk the full field area. We also were able to offer field experiences to students from underserved communities who may have been put off by the image of a field geologist as a male, boot-wearing, plaid shirt-wearing, geologist (add your tropes here)."

Access to New/Distant Places (12)

"It also gives us another teaching tool, and the ability to 'take' students to places that we might not be able to get to otherwise due to distance or expense (e.g., Iceland)."

Student Engagement/Performance (13)

"More diversity of locations, can go to the type location of something."

"Students who participated in the virtual field trip reported a high degree of satisfaction."

Student Skills/Success/Professional Development (6)

"Students being able to do the tasks...and feeling less overwhelmed by completing the tasks in the field."

Supplementary to Field Work (5)

"The virtual field experiences provide a great opportunity to train students prior to in-person exercises."

	<i>Time/Resource Flexibility (1)</i>	"More flexibility with timing of field trips, less competition for equipment/resources with other classes."
	<i>Transportation Costs/Logistics (6)</i>	"Virtual experiences cost less than traveling to the actual location." "Damage to rental vans."
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DESCRIBE DEI (42)		
	<i>Income/Cost/Expense (3)</i>	"The virtual trips are accessible to students who do not have the financial means to attend in-person trips."
	<i>Family/Work/Other Previous Obligations (7)</i>	"Allow for teaching students that otherwise cannot go to the field for family, job, or health reasons."
	<i>Health Issues/COVID (5)</i>	"Isolating due to contact tracing for COVID." "Students with preexisting health conditions were able to fully participate in the activities."
	<i>Broader Participation (9)</i>	"...we got more participation from students who may have been reluctant in the past to participate in field work owing to unfamiliarity or rejection of some of the common tropes about geologists."
	<i>Marginalized/Underrepresented/Cultural (5)</i>	"I work with Navajo students that have cultural prohibitions from visiting certain localities but are able to participate in a virtual setting."
	<i>Physical Disability/Mobility (10)</i>	"These allowed students who were otherwise unable to attend due to physical disabilities."
	<i>Universal Student Experience (3)</i>	"The ability for differently resourced students...to be able to experience some of the benefits of field trips..."
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FUTURE NEEDS (61)		
	<i>Inclusion/Accessibility (1)</i>	"Low or no additional cost to students."
	<i>Funding/Administrative Support (6)</i>	"Funding for travel." "Financial support to develop exercises."
	<i>Faculty Time/Skills (16)</i>	"The major problem at my university is (1) managing the time demands of faculty and (2) providing them with sufficient incentive to undertake curriculum development such as this. The most important resource is sufficient compensation in terms of time..."
	<i>Materials/Software/Technology (31)</i>	"A library of options would be useful. Just sharing information about others' experiences with virtual field trips, how they worked, etc., would be quite helpful." "Equipment is one area that may need improvement."
	<i>None/Not Sure/NA (7)</i>	"Nothing I can think of. Our university has done a great job of making sure that students have IT resources."
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FUTURE USE – WHY (69)		
	<i>Inclusion/Accessibility (12)</i>	"I think they offer a great opportunity for inclusiveness of people with mobility or other disability issues that cannot easily take part in traditional field courses."
	<i>COVID Restrictions/Shutdowns (2)</i>	"We think it's a good idea to have some of these planned in case COVID gets bad again, but it hasn't happened yet."
	<i>Currently In Use/In Development (17)</i>	"We will continue to explore virtual field experiences to provide students options." "They're great, I'm glad I found them and want to continue to use them."

<i>Environmental Factors (2)</i>	"I now plan to run the virtual field trip earlier in the spring semester (when it is too cold to go into the field) before running the same trip in-person late in the spring semester."
<i>Access to New/Distant Places (7)</i>	"We can see a broader array of sites." "Possibility of digitally preserving access to transient or hard-to reach geological features."
<i>Resources/Costs (3)</i>	"Liability issues are non-existent in virtual trips."
<i>Student Engagement/Performance (5)</i>	"Has been useful to engage students and attract some of them to try real-world field experiences."
<i>Supplementary to Field Work (12)</i>	"Instead of offering virtual experiences instead of in-person trips, we offer them in addition to in-person trips."
<i>Worth Attempting for Various Reasons (9)</i>	"It is yet another tool in the toolbox." "I think we're open to trying anything that could potentially be beneficial (and pedagogically sound) for our students."
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FUTURE USE – WHY NOT (42)	
<i>Lack of Administrative/Faculty Support (8)</i>	"As an in-person, residential college, it is not a priority to develop our virtual offerings to any extent. There is no support in the College for this kind of pedagogy."
<i>In-Person is Preferred (10)</i>	"We are largely returning to our hands-on, field-based experiences, which we believe are formative for geoscience skills." "Faculty and students prefer in-person field trips, thus, we never considered virtual field trips."
<i>Faculty Time/Skills (5)</i>	"I don't plan to offer separate virtual field trip courses, even though they could be valuable. There just isn't enough time in the day to [create] these."
<i>Not a Good Substitute (18)</i>	"Field experiences should be in the field." "Hands on, in-person learning is a critical component of a field experience, and the department does not advocate virtual experiences as a substitute for in-person experiences."
<i>Student Interest/Enrollment (1)</i>	"Depends on number of majors, perhaps."
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FUTURE USE – UNDECIDED/UNSURE (2)	"Undecided about the future of them; could be a course-by-course or lab-by-lab decision."

Supplementary Table 2. *Representative responses and example excerpts from the survey of instructors.*

COVID MODIFICATIONS (38)		
<i>COVID Safety Plans Required (1)</i>		"A COVID safety plan is now submitted with required field trip travel authorizations."
<i>Field Trips Cancelled/Postponed (14)</i>		"We canceled all in-person field trips during the pandemic, including two summers of field camp."
<i>Independent Field Study (1)</i>		"Students had to find their own field sites without instructor involvement."
<i>Few to None/NA (1)</i>		"None – impossible"
<i>Masks/Distancing/Other COVID Requirements (5)</i>		"Masking in vans during transport, maintaining social distancing during site visits."
<i>Developed or Used Remote/VFES/Other (14)</i>		"We ran all field trips virtually for Summer 2020&2021, and the 2020-2021 academic year."
<i>Shorter/Localized Trips (2)</i>		"Shortened to single days with students providing their own transportation." "Trips closer to campus and remaining in Alabama."
CLASS VFE MOTIVATIONS (22)		
<i>Inclusion/Accessibility (4)</i>		"Alternate assignments for students who couldn't come out into the field (accessibility)."
<i>Access to New/Distant Places (4)</i>		"Distance was too far, wanted to teach about a field site for a specific topic (turbidites)."
		"Ability to go to many locations."
<i>COVID Restrictions/Shutdowns (4)</i>		"Travel limited by COVID."
<i>Better Than Nothing (1)</i>		"Better than no field experience at all."
<i>Did Not Use/NA (1)</i>		"I did not use these in place of class field trips."
<i>Student Skills/Success/Professional Development (4)</i>		"Need for field experience."
		"Try to bring the field to the students."
<i>Transportation Costs/Logistics (4)</i>		"Cost of travel to destinations sought outside our local area."
CLASS VFE BARRIERS (27)		
<i>Materials/Software/Technology (5)</i>		"In Spring of 2020 to Spring 2021, a lack of on topic materials." "Software processing was too time consuming."
<i>Few to None/NA (1)</i>		
<i>Inclusion/Accessibility (1)</i>		"Some concerns about accessibility (e.g., closed captioning)."
<i>Faculty Time/Skills (2)</i>		"Time, time, and time. There is not enough time to develop these types of resources. They take a ton of time. Knowledge, not sure how to implement this type of modality."
<i>Not a Good Substitute (8)</i>		"There is no substitute for actually observing rocks on field trips in my opinion – you can teach other/complimentary skills, but not the real deal, at least with current technology." "A huge step down from the real McCoy."
<i>Student Skills/Success/Professional Development (4)</i>		
<i>Student Engagement/Performance (6)</i>		"Hard to get them to explore on their own." "About 1/3 of Physical Geology students were very reluctant to take on the additional research responsibilities that I assigned. Some students failed to participate (which of course would not happen with an actual field trip)..."
CLASS VFE BENEFITS (21)		

	<i>Mixed Instructional Methods (3)</i>	"Way to work with students both in classroom and hybrid (online)."
	<i>Few to None/NA (4)</i>	"Able to mix field observations with classroom discussions rapidly. Interact with different media."
	<i>Inclusion/Accessibility (4)</i>	"Very very few – using a Brunton on plywood in a lab to measure strike/dip does not replace the field."
	<i>Access to New/Distant Places (3)</i>	"...non-traditional students did not have their work (or study) schedules interrupted by weekend field trips."
	<i>Student Skills/Success/Professional Development (3)</i>	"Can visit locations all over the world." "Can visit type locations for specific needs."
	<i>Supplementary to Field Work (2)</i>	"Using...an independent research project that was then presented before the class via PowerPoint, many students learned much more about their subjects than would otherwise have happened. In addition, they learned about documenting time on task by maintaining a work journal with on-site photo documentation (which is a useful work skill)."
	<i>Transportation Costs/Logistics (2)</i>	"Virtual 'fieldwork' is a decent approximation to the type of pre-field work that we do when preparing for a research expedition..." "Nice introduction to locations and features that students will be visiting in the field." "Lower expenses for the travel budget..." "...less travel, and students did not have to be present."
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FIELD COURSE VFE MOTIVATIONS (27)		
	<i>Better Than Nothing (1)</i>	"Better than no field experience at all."
	<i>COVID Restrictions/Shutdowns (6)</i>	"Mandated to go remote, couldn't officially hold face-to-face classes. Field trips were off limits."
	<i>Did Not Use/NA (17)</i>	
	<i>Inclusion/Accessibility (2)</i>	"Replacement activities for people who were injured or sick at field camp."
	<i>Student Skills/Success/Professional Development (1)</i>	"For handicapped access." "We needed activities that would teach mapping and observational skills but did not require field work."
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FIELD COURSE VFE BARRIERS (25)		
	<i>Faculty Time/Skills (5)</i>	"We generally don't have the skills to make our own advanced virtual experiences."
	<i>Few to None/NA (6)</i>	
	<i>Inclusion/Accessibility (1)</i>	"Some concerns about accessibility (e.g., closed captioning)."
	<i>Materials/Software/Technology (2)</i>	"We're stuck using pre-made exercises, which we cannot customize."
	<i>Not a Good Substitute (4)</i>	"Virtual experiences may help students prepare for later in-person field work/classes, but they absolutely 100% do not at all function as a substitute."
	<i>Student Engagement/Performance (1)</i>	"They clearly don't engage as deeply with the material as when they are working in a remote location – the transition from 'classroom' to 'field' never actually occurs. It's hard to not make some aspects feel like busy work."
	<i>Student Skills/Success/Professional Development (6)</i>	"Students could not comprehend scale." "Despite their reputation, our students are not actually very technically adept..."

**FIELD COURSE VFE
BENEFITS (23)**

<i>Access to New/Distant Places (1)</i>	"Broader location of field sites can be visited virtually than in-person."
<i>Course Completion (1)</i>	"Was able to finish the class, otherwise would have been required to give students incomplete."
<i>Few to None/NA (7)</i>	"Very, very few if one is to avoid a sight-seeing/'ooh-wow' situation."
<i>Inclusion/Accessibility (7)</i>	"Practically none for a 'true' geology program." "Accessibility for the students, especially those students of marginalized communities that may not have been able to attend face-to-face field trips." "Allows students who have family obligations and can't easily leave for 5-6 weeks to participate in a capstone educational experience."
<i>Student Skills/Success/Professional Development (5)</i>	"Students gain more experience with remote sensing data." "Certain steps that are often lumped in field experiences could be broken down into small bites."
<i>Supplementary to Field Work (1)</i>	"We now use one virtual landscapes mapping project in the classroom prior to our main field work."
<i>Transportation Costs/Logistics (1)</i>	"Less travel and time away from home for me, the instructor, and also for the students..."

DESCRIBE DEI (15)

<i>Income/Cost/Expense (2)</i>	"Costs, transportation, time, are all an issue for many of the students from [underrepresented/marginalized] communities."
<i>Family/Work/Other Previous Obligations (2)</i>	"Medical/family issues that make it difficult to spend a day or more in the field." "Students who cannot give any of their weekend time to coursework due to childcare, need to work, etc."
<i>Health Issues/COVID (2)</i>	"Several students with health problems that would not have been able to complete geology field camp were able to do our virtual field camp."
<i>Broader Participation (3)</i>	"All students could participate, regardless of physical or cultural differences."
<i>Marginalized/Underrepresented/Cultural (1)</i>	"Students from marginalized communities were able to experience virtual trips when they could not actually attend the actual field trip."
<i>Physical Disability/Mobility (2)</i>	"A great way to include students with physical limitation (temporary or permanent)."
<i>Universal Student Experience (3)</i>	"All experienced same thing." "Many students are uncomfortable in the field."

FUTURE NEEDS (61)

<i>Inclusion/Accessibility (1)</i>	"Improved accessibility features for students who need them (e.g., closed captioning, etc.)"
<i>Administrative Support (4)</i>	"Support from administrators for technical/field help and equipment both in the field and on campus...that is not happening because these administrators view such activities as junkets/holidays."
<i>Faculty Time/Skills (8)</i>	"For a major multi-day field trip or Field Camp, (paid) summer time for course development would make it possible to spend the time/energy needed to develop a quality VFE."
<i>Materials/Software/Technology (16)</i>	"Clearinghouse or collaborative virtual hand samples and outcrops."
<i>None/NA (2)</i>	"Help with pedagogy, help with technology (select/use), [money] for student technology."

<i>Student Interest/Enrollment (2)</i>	“For my virtual field camp to continue, I would need students to apply to it. I haven’t been able to run it because there isn’t the demand. I have advertised it and still only one or two students a year, which is not enough to run it.”
FUTURE USE – WHY (69) <i>Inclusion/Accessibility (8)</i> <i>COVID Restrictions/Shutdowns (1)</i> <i>Currently In Use/In Development (6)</i> <i>Student Skills/Success/Professional Development (1)</i> <i>Access to New/Distant Places (2)</i> <i>Resources/Costs (2)</i> <i>Student Engagement/Performance (1)</i> <i>Supplementary to Field Work (5)</i> <i>Worth Attempting for Various Reasons (4)</i>	“We are working on a field camp that is more accessible and will use virtual field experiences as part of it.” “When not able to go to locations physically due to COVID-19 or other constraints.” “Working on multiple virtual experiences to afford access to those who can’t.” “Developing virtual reality field trips to geologic features for use in 100-600 level courses.” “Students will likely benefit from the experience of thinking in 3D and mapping out structures in a virtual environment.” “This is needed because of logistical questions (100-student classes far from real rocks).” “Matter of costs having to be reduced.” “Was effective in engaging students.” “...my co-instructors have discussed opportunities to incorporate VFEs in the initial portion of field camp to refresh or introduce field and mapping skills.” “I am interested in incorporating Minecraft geological mapping into the introductory curriculum.”
FUTURE USE – WHY NOT (42) <i>Resources/Costs (4)</i> <i>In-Person is Preferred (5)</i> <i>Faculty Time/Skills (4)</i> <i>Not a Good Substitute (4)</i> <i>Student Interest/Enrollment (2)</i>	“...At our institution we are interested in developing virtual exercises to expand our educational opportunities. However, we do not have the resources to devote to continue to develop and maintain a full virtual field camp experience as the number of students who need it is small.” “Students (and faculty) are growing increasingly weary of screen time. Most of the courses I teach are highly dependent on face-to-face interactions.” “If I didn’t have such a high workload already, I would have a different answer, but as things are now there simply isn’t time to run 2x field camp.” “VFEs do not properly substitute or really augment ‘field camp’ type courses, only slow them down and over-complicate things.” “...I do not think they can substitute for actual field work in a meaningful way.” “...the number of students who need it is small.”