H. Söbke, J. Baalsrud Hauge, M. Wolf, & F. Wehking (eds.):
Proceedings of DELbA 2020
Workshop on Designing and Facilitating Educational Location-based Applications
co-located with the
Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020)
Heidelberg, Germany, Online, September 15, 2020

Virtualization of Virtual Field Trips

A Case Study from Higher Education in Environmental Engineering

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Abstract. Field trips foster sustainable high-quality learning outcomes and are therefore one of the cornerstones of teaching in various disciplines. However, field trips are costly and less compatible with some teaching formats, such as distance learning. Using the example of a lecturer-guided field trip through a city quarter on the topic of infrastructure planning, the four-staged evolution of this lecturer-guided field trip via a location-based app guided field trip and via a virtual field trip to a virtualized virtual field trip (VVFT), in which all participants group-wise conduct the field trip at different locations using a 360-degree model and video conferencing, is described. A qualitative evaluation by means of guided interviews proves the usefulness of this learning activity, which is to be recommended for future advancements.

Keywords: virtual field trips, location-based apps, 360-degree models, video conferencing, distance learning, virtualized virtual field trip

1 Introduction

Field trips are an established learning activity that leads to high-quality learning outcomes [1]. Further, field trips are seen as conducive to student interest, knowledge and motivation [2]. Among the learning-relevant characteristics of field trips are direct learning and concrete interaction with the environment [3]. However, the feasibility of field trips is in part questioned, for example when it comes to cost-benefit considerations or the avoidance of real-world risks for students [4].

The disadvantages of field trips can be compensated by so-called virtual field trips (VFTs). Tuthill and Klemm define VFTs as "to bring the sights and sounds of a dis-

tant place into [...] classroom through a computer" [5]. VFTs are seen as a way to replace field trips or hands on learning sessions at least in part and still contribute to a quality learning experience with the help of technology [6]. Recent technological developments used to create VFTs include 360-degree technology [7–9].

Learning is stimulated by interaction with fellow students [10]. For example, team-based learning is considered a successful teaching approach [11]. Groups of learners are also a prerequisite for the learning theory of situated learning [12]. Further, it has been shown that small groups lead to improved learning outcomes and improved skill acquisition [13]. All these arguments suggest that – even if VFTs can be conducted by students individually – VFTs ought to be conducted in groups of students. However, group-wise learning activities are less feasible in various teaching formats, such as distance learning or – as happening currently – teaching formats induced by epidemics. In those teaching formats, commonly students are at different locations, being separated from each other. A potential mitigation is connecting the students through video conferencing. Although the use of video conferencing for VFTs (e.g. [14]) and the mapping of VFTs by 360-degree models is not new, the combination of these technologies to replicate lecturer-guided field trips conducted by groups of students is to the best of our knowledge not yet described in the literature.

Therefore, this article studies a learning scenario using a 360-degree model for a VFT that was previously conducted as a lecturer-guided field trip. To free students from the need to be in a common location, the VFT is transformed into a virtualized virtual field trip (VVFT) using video conferencing. All students of each group are in a common group-specific video conferencing room to conduct the trip together. The research questions of this explorative study are as follows:

- Do VVFTs function technically and organizationally? (RQ 1)
- What effects do VVFTs have on learning especially from the perspective of the students? (RQ 2)
- What are the advantages and disadvantages of VVFTs compared to field trips? (RQ 3)

Methodologically, guided interviews are conducted with one member of each group (N=10) subsequent to the VVFT. The further article is structured as follows: The next section describes the learning scenario and its four development stages. Section 3 summarizes the qualitative findings of the exploratory study. Thereafter, the findings and its limitations are discussed in Section 4. Finally, Section 5 presents the implications of the findings and suggests further measures.

2 Learning scenario

This section describes the development of a field trip from the original lecturer-guided stage to a stage in which all participants at different locations virtually execute the field trip using video conferencing.

Lecturer-guided field trip. The core of this learning scenario is a field trip to a local city quarter in Weimar, Germany. This city quarter was built during the transition to the new millennium on the former site of a Russian barracks and comprises about 40 single-family houses. The field trip is part of the bachelor course *Urban Water Management*, which covers in particular the planning of water infrastructure, such as wastewater disposal, rainwater management and drinking water supply. In previous courses, the field trip is embedded in a learning activity in which the field trip follows a lecture and is succeeded by a hypothetical planning of the infrastructure for wastewater disposal. The lecturer-guided field trip lasts about 60 minutes, during which the wastewater disposal-relevant points of interests (POIs) of the city quarter are explained by the lecturer.

App-guided field trip. The availability of location-based apps led to the development of a field trip, which is conducted in small groups of two to four students guided by a location-based app [15]. In contrast to the lecturer-guided field trip, where individual students might also reduce their involvement without immediate consequences, the inclusion of each student in the field trip is intended to stimulate the engagement of all students and to foster high-quality learning outcomes for all students. Especially, the splitting into small groups is considered important to foster engagement and to promote learning. For increasing engagement, at each POI, questions have to be answered using the location-based app. The app-guided field trip was positively received by the students and completed highly motivated [15].

Virtual field trip based on 360-degree models. The app-guided field trip requires the students to be on site. This requirement limits the number of participants in the learning scenario. One option for opening the learning scenario to other participants are 360-degree models. Thus, using a standard 360-degree camera, the relevant POIs of the city quarter were recorded. Together with 360-degree images of intermediate points, which facilitate the visualization of the walking tour, a 360-degree model was compiled: The software *Pano2VR* [16] merges the individual images into a single 360-degree model. Information on the POIs, which were previously provided by the lecturer or the app, is now available as annotations. The 360-degree model is available via web-browser. The questions to be answered for each POI are provided via a learning management system (Moodle). All in all, this approach allows transferring app-guided field trip one-to-one to VFTs and thus provides the app-guided field trip virtually to students from further institutions.

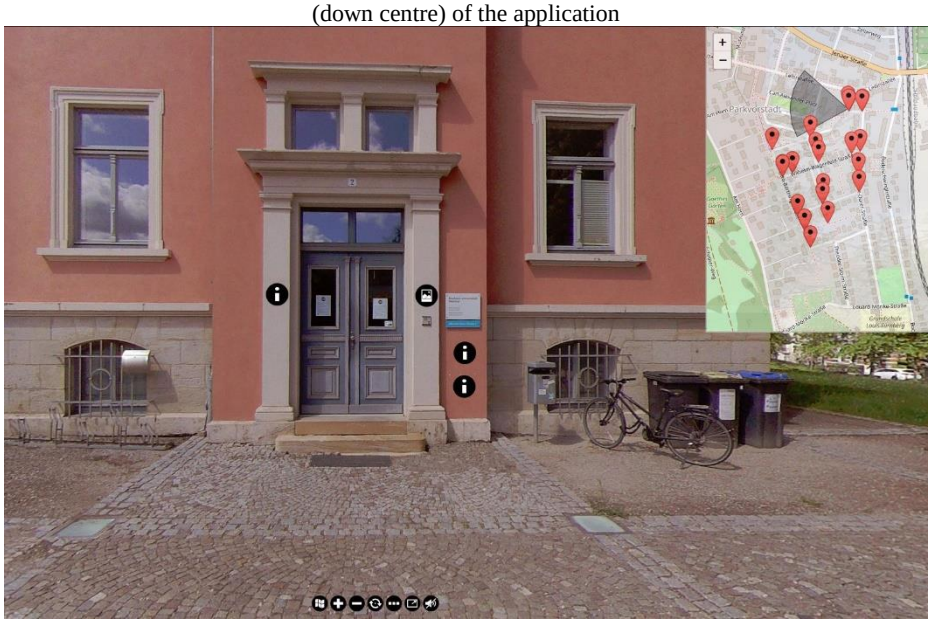
Virtual field trip based on 360-degree models and video conferencing. Based on the virtualization of the field trip presented in the previous paragraph, the location dependency of the scenario has already been partially resolved. However, it is still necessary for all members of the group to be at the same location at the same time. Video conferencing is intended to overcome this limitation. All members of a group – usually three –, each having different roles, join in a virtual video conferencing room. One of the members operates the 360-degree model. By sharing the desktop within

the video conference, the other two members of the group may also participate in the virtual walkthrough of the 360-degree model. The other two members of the group also are assigned tasks: One member records a protocol about information on the POIs visited. The third member is in charge of answering questions in Moodle about the POI visited. The information on each POI and the correct answers to the questions may be discussed in the group as much as the 360-degree model operator is guided through the 360-degree model by the other two members of the group.

3 Results

A total of 28 students in 10 groups took part in the VVFT. The VVFT took them between 46 and 90 minutes.

Fig. 1. Starting POI of the VFT: Screenshot, showing the map (upper right) and the controls (down centre) of the application



The guided interviews were structured according to the research questions. Therefore, in the following, the results are presented with reference to the research questions.

3.1 Technical and organizational requirements (RQ 1)

VVFTs imposes high demands both from a technical and an organizational point of view. Therefore, the feasibility of VVFTs in general and the requirements of this learning scenario in particular are impacted by the aspects following.

Technical problems. Positive to be mentioned is the occurrence of no serious technical problems that would have caused the termination of the VVFT. However, some groups reported bandwidth problems, which resulted in pixelated images and frame jumps, rendering the VVFT more difficult. Another group stated high processing power consumption for the computer running the 360-degree model.

Supervision by lecturer. The lecturer waited in another virtual video conference room during the VVFT, half of the group consulted him during the VVFT. Because of the communication connection that is already in place, it is easy to provide support for any questions. One group suggested a chat connection to the lecturer. Another group would have liked to have the teacher permanently present.

Social presence. A challenge of online learning scenarios compared to face-to-face learning scenarios is social presence and group dynamics. In this learning scenario, the groups mostly found together on their own; it was possible to build on already existing social structures. Positive group dynamics were also reported. Thus, as hoped for in the conception of the learning scenario, there were agreements about the movements in the 360-degree model, democratic decisions about the answers to be given and discussions about the information presented. The proposed distribution of roles was positively received. The cooperation in the groups was reported as good throughout.

Handling time. Some groups requested more time to be able to in-depth discussions. Most of the groups finished within the given time.

Augmentations. In several interviews, the information given was described as to be extended, the groups requested more information. Although the learning scenario was described as appropriate for a bachelor course, additional information was requested. In particular, the addition of information on hidden structures was also considered useful. For example, the location and extension of an underground car park are not recognizable, but the extension is important for the planning of sewage pipes to be placed in the underground.

3.2 VVFT as learning activity (RQ 2)

The VVFT aims at learning outcomes. Due to the structure changed compared to a field trip, the suitability of the VVFT for learning requires further investigation.

Learning outcomes. Overall, all groups confirmed that the contents of the learning scenario are adequate for a bachelor course. All groups also agreed that they would participate voluntarily in further VVFTs. The subjectively achieved learning outcomes were seen as inconsistent: Both existing knowledge was consolidated and new

knowledge was acquired. The transfer of existing knowledge to a concrete situation was often mentioned as an significant contribution of the VVFT to the learning outcomes. Here the VVFT was positioned as a supplement to a lecture. The connection with the lecture was considered essential – consequently, a VVFT requires a prior briefing. The comparison of VVFTs with museums was drawn.

Cognitive presence. It was confirmed that the design of the learning scenario based on groups and roles ensures that all learners are involved and cannot simply lean back. In field trips, on the other hand, some of the students are easily distracted, for example by their smartphone.

Learner profiles. One student explained her positive impression of the VVFT with her rather visual learner profile. Her statement suggests that VVFTs might be a complementary learning activity appropriate for certain learner profiles.

Discourse. The majority of the groups referred to the discussions that were emerging during the VVFT. Discussions fostered might be regarded as indication of the educational value of VVFTs.

3.3 VVFTs compared to field trips (RQ 3)

The aim of the third research question is determining differences between VVFTs and field trips from the students' perspective for being able to eliminate shortcomings and to strengthen advantages.

Comparison to field trips. A field trip differs from conventional learning activities, such as lectures, due to organizational effort and differing locations. So it is not surprising that all groups stated field trips not being replaceable completely by VVFTs. When asked in an abstract question about the proportion of a field trip that could be replaced by a VVFT, an average of 60 % was indicated.

Orientation. The orientation being in a 360-degree model is certainly more challenging compared to a field trip. Therefore a question to the groups was how easy the groups could orientate in the 360-degree model. The majority of the groups answered the orientation was quite possible and the map (Fig. 1) was an important tool for orientation. Almost all groups reported that they also looked around at the POIs. To improve orientation, it was requested to indicate on the map the path to be taken. One group suggested to visualize the path to be taken directly in the 360-degree model.

Advantages of VVFTs. Following are various aspects that were mentioned in the interviews as advantages of VVFTs.

- Once it was noted that the 360-degree model was also still used in the subsequent planning activity. This would be not possible for field trips, in which planning must be done completely from memory.
- Due to the tools that the students have at their disposal on their computers, it is possible to look up other documents on the web when VVFTs are in progress. Further multimedia information can also be integrated into the 360-degree model.
- VVFTs are cost- and time saving compared to field trips and can be conducted while being in home office.
- In field trips frequently the problem arises that students do not hear acoustically everything that the lecturer utters, because, for example, students are too far away from the lecturer. Using VVFTs, the conditions are the same for everyone.
- VVFTs are an alternative especially if the field trip locations are far away.

Shortcomings of VVFTs. Some shortcomings of VVFTs were also mentioned, as described below.

- Certain phenomena are not easily detectable in VVFTs. For example, the inclination of the ground surface required to determine the flow direction in wastewater pipes cannot always be clearly identified using 360-degree technology. Soil structures are also not so well recognizable.
- The majority of the groups pointed out that in field trips more attention is paid to the surroundings. In the VVFT, on the other hand, students hopped from POI to POI, often without paying attention to details in between, so that small details were sometimes overlooked.
- A field trip potentially provides more additional knowledge, as the lecturer might tell further stories about the location and there is the chance for students to ask questions.

4 Discussion

The learning scenario presented has significant advantages, such as the availability for a much larger group of students due to the elimination of location dependencies. However, a major disadvantage is an increasing dependency on technology in the development chain from lecturer-guided field trip to VVFT (Table 1). A higher reach of the scenario is bought at the price of an increasing technology dependency.
The use of video conferencing initially ruled out the possibility of immersive VR. Immersive VR requires a headset for the user of the 360-degree model. Technically, the employment of immersive VR is not completely impossible in the learning scenario described, but it does increase the technical effort, since headsets are required whose video output would also have to be transmitted to an external monitor. The requirements for the individual members of a group also diverge. Both arguments have led to the decision not to use immersive VR in this study.

Furthermore, the time and effort required to prepare the VFT underlying needs to be discussed. For the case study, about 4 working days were spent on taking 360-

degree images, on linking the 360-degree images and on enriching the 360-degree model with didactical annotations. The effort is considerable and requires skills that lecturers do not necessarily have. In the future, authoring systems that are easier to handle might be a remedy. However, once the 360-degree model is available, the actual effort demanded from lecturers can be considered as low.

Table 1. Field trip development stages and requirements

Field trip development stage	Requirements
Lecturer-guided field trip	General – Presence at location for lecturer and entire cohort
Location-based app-guided field trip	General – Presence at location for entire cohort Technical – Mobile devices using internet connections and location-aware sensors – Virtual tour management software
Virtual field trip based on 360-degree models (VFT)	General – Groups need to be present at the same location Technical – Computer per group – 360-degree model software and server – Internet connection
Virtual field trip based on 360-degree models and videoconferencing (VVFT)	Technical – Computer per student – 360-degree model software and server – Internet connection – Video conferencing

A limitation of the present study is the lack of a didactic framework and awareness of the generally achievable learning outcomes. Based on the general conclusion that field trips can contribute to high quality learning experiences, the study is limited to the rather technical extension of VVFTs. The use of a didactical framework might constructively lead to increased learning outcomes. Also, the achievable learning outcomes might be estimated specific to each discipline.

An important principle when comparing the learning efficiency of different learning scenarios is the comparability of the information provided for learning. In a field trip, the lecturer has a major impact: the amount of information provided during a field trip depends on the lecturer guiding the field trip. In the VVFT the information is conveyed in a predetermined quantity and manner, so that a VVFT is to be seen as standardized with regard to the information given, while the information given in the field trip can change not only depending on the lecturer but also on the environmental conditions at the time of the field trip.

The underlying VFT learning scenario certainly cannot reach the same learning outcomes that a real field trip can achieve. For example, the inclination of the ground surface in the field trip are much better recognizable than this is possible in the VFT. The benefit of VFTs (and thus also of VVFTs) is rather the increase of the variety of learning activities and especially - considering limited cost and time budget for field trips - a higher quality learning experience compared to other multimedia-based learning tools, such as websites or further digital documents.

5 Conclusions

With the help of 360-degree models and video conferencing, location dependencies of field trips are eliminated. Students do not have to be on site, nor do they have to be in the same location. This opens up the field trip to more students as well as to other teaching formats, such as virtual teaching during epidemics or distance learning formats in general. A qualitative evaluation has shown the potential of the format of *virtualized virtual field trips* (VVFTs). Although the experiences of VVFTs are not comparable to field trips, the high level of vividness of this teaching format contributes to high-quality learning experiences, which stand out from the currently offered teaching formats as acknowledged by the students interviewed. In addition, this article documents the development of a VVFT from a lecturer-guided field trip using the intermediate stages location-based app-guided field trip and virtual field trip (VFT). Future research will aim at complementing VVFTs with further interaction possibilities and more details, at identifying the shortcomings especially from a didactic point of view, and at providing libraries of VVFTs for optional learning activities and thereby increasing the variability of learning activities and complementing field trips. The study renders VVFTs using 360-degree models and videoconferencing systems as an efficient approach to imparting practical experience without the disadvantages of high cost, effort, and time required for travel.

References

1. Falk, J.H., Dierking, L.D.: School Field Trips: Assessing Their Long-Term Impact. Curator Museum J. 40, 211–218 (1997).
2. Behrendt, M., Franklin, T.: A Review of Research on School Field Trips and Their Value in Education. Int. J. Environ. Sci. Educ. 9, 235–245 (2014).
3. Orion, N., Hofstein, A.: Factors that influence learning during a scientific field trip in a natural environment. J. Res. Sci. Teach. 31, 1097–1119 (1994).
4. Herrick, C.: Lost in the field: Ensuring student learning in the “threatened” geography fieldtrip. Area. 42, 108–116 (2010).
5. Tuthill, G., Klemm, E.B.: Virtual field trips: Alternatives to actual field trips. Int. J. Instr. Media. 29, 453 (2002).
6. Turney, C.S.M., Robinson, D., Lee, M., Soutar, A.: Using technology to direct learning in higher education: The way forward? Act. Learn. High. Educ. 10, 71–83 (2009).

7. Chang, C.Y., Lin, M.C., Hsiao, C.H.: 3D compound virtual field trip system and its comparisons with an actual field trip. Proc. - 2009 9th IEEE Int. Conf. Adv. Learn. Technol. ICALT 2009. 6–7 (2009).
8. Klippel, A., Zhao, J., Oprean, D., Wallgrün, J.O., Stubbs, C., La Femina, P., Jackson, K.L.: The value of being there: toward a science of immersive virtual field trips. Virtual Real. (2019).
9. Pham, H.C.A.I.C., Dao, N.N., Pedro, A., Le, Q.T., Hussain, R., Cho, S., Park, C.S.I.K.: Virtual field trip for mobile construction safety education using 360-degree panoramic virtual reality. Int. J. Eng. Educ. 34, 1174–1191 (2018).
10. Webb, N.M.: Peer interaction and learning in small groups. Int. J. Educ. Res. 13, 21–39 (1989).
11. Michaelsen, L.K., Knight, A.B., Fink, L.D.: Team-based learning: A transformative use of small groups in college teaching. (2004).
12. Lave, J., Wenger, E.: Situated learning: legitimate peripheral participation. Cambridge University Press (1991).
13. Brindley, J.E., Blaschke, L.M., Walti, C.: Creating Effective Collaborative Learning Groups in an Online Environment. Int. Rev. Res. Open Distrib. Learn. 10, (2009).
14. Zanetis, J.: The beginner's guide to interactive virtual field trips. Learn. with Technol. March/Apri, 20–23 (2010).
15. Wolf, M., Wehking, F., Söbke, H., Londong, J.: Location-based Apps in Environmental Engineering Higher Education: A Case Study in Technical Infrastructure Planning. In: Söbke, H., Baalsrud Hauge, J., Wolf, M., and Wehking, F. (eds.) Proceedings of DELbA 2020 - Workshop on Designing and Facilitating Educational Location-based Applications co-located with the Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020) Heidelberg, Germany, Online, September 15, 2020 (2020).
16. Garden Gnome Software e.U.: Pano2VR, https://ggnome.com/pano2vr/, (2020).