Self-Guided Smartphone Excursions in University Teaching—Experiences From Exploring "Water in the City"

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Like many other university teachers, we were faced with an unprecedented situation in spring 2020, when we had to cancel *on-site* teaching and excursions due to the Covid-19 pandemic. However, we were in the fortunate position that we had already started to develop a smartphone-based self-guided excursion on the topic of "Water in the City". We accelerated this development and used it to replace the traditional group excursion in our Bachelor level introductory course in Hydrology and Climatology. The excursion of this course is visited by around 150 students each year. Because the student feedback was overall very positive, we used the self-guided excursion again in 2021 and plan to continue to use it in the coming years. In this paper, we describe the excursion, discuss the experiences of the students and ourselves, and present recommendations and ideas that could be useful for similar excursions at other universities.

Keywords: field trip, undergraduate teaching, hydrology, mobile phone, treasure hunt, student evaluation

INTRODUCTION

By being out of the classroom and in the real world, excursions and field trips are unique experiences and are often among the most memorable days of a study (Djonko-Moore and Joseph, 2016). The new or unconventional site for learning and teaching has a motivating effect on the students (Hasse and Colvard, 2006; Herrick, 2010; Gašparová and Kyseľová, 2020; Holgersen, 2021). Excursions and field trips, furthermore, provide students with the possibility to make observations on their own and to strengthen their understanding by seeing—in real life—what they learned in theory in the classroom (Jonasson, 2011; Kingston et al., 2012; Krakowka, 2012; Djonko-Moore and Joseph, 2016). This can provide them with an idea of the value of their newly acquired knowledge. Thanks to the authentic learning context and examination of real-world problems, the knowledge obtained during excursions can be applied to new tasks that students are subsequently confronted with. This makes excursions and field trips especially valuable and effective (Brickell and Herrington, 2006; Fränkel et al., 2020).

However, excursions and field trips, especially large group excursions, also have disadvantages. Especially in loud environments or windy areas, students standing in the back of the group may have difficulties hearing the instructor and, thus, may miss parts of the content (Moore et al., 2011; Wissmann, 2013). Moreover, it is not possible to adjust the speed of the excursion to the individual needs of students (Larsen et al., 2020). This applies to both the content (some students need more background information or more detailed explanations than others) and physical speed (some students walk faster than others). Students who learn at a slower pace, students for whom the contents of the excursion are very new, and students who are not native speakers may need some extra time to think about the contents of the excursion and to understand them. For others, the pace

may be too slow, so that they become bored and distracted. Furthermore, the different levels of fitness among students may result in a walking speed that does not fit everyone, so that the excursion becomes a physical challenge for some and is too slow for others.

Excursions also require significant time for preparation, to be carried out, and, in some cases, grading. Thus, the workload for instructors can be relatively large. The time requirement for instructors becomes especially large if large classes have to be split into smaller groups to keep the group size reasonable and the excursion has to be repeated multiple times, or when excursion reports have to be graded. Although the time commitment for each excursion is smaller if the excursion is repeated several times, this time benefit is limited. In addition, there are costs related to excursions, e.g., transportation and lodging, so the number of students that can be taken on an excursion is often limited. Due to these financial costs and time constraints, the number of excursions that are part of a curriculum has decreased for many university programs (Herrick, 2010; Larsen et al., 2020), even though they are considered important for learning, especially in geography and earth and environmental sciences (Jonasson, 2011).

Excursions with out an instructor to lead the group and explain the contents may remedy some of the issues for large group excursions described above. Different approaches and new technologies can be used to support excursions and field trips, e.g., a web interface with additional information on a real-world problem (Brickell and Herrington, 2006), or podcasts to support learning in the field (Jarvis and Dickie, 2010). Mobile guides (Moore et al., 2011; Fränkel et al., 2020) or a combination of mobile guides and paper workbooks (Wissmann, 2013) allow students to visit the sites of an excursion on their own, without an accompanying instructor.

Audio tours (Wissmann, 2013) and self-guided visits of sites close to campus (Moore et al., 2011) ensure that each student hears and sees the information taught during the excursion. Students are more independent and can experience the excursion at their own pace if they do an excursion individually or in small groups (Herrick, 2010). This means that they can look up terms that they do not understand, access background information, or repeat some parts if needed. Furthermore, it is easier to implement theoretical aspects into the written descriptions of self-guided excursions than to talk about these during a normal group excursion. Thus, the important connection between theory and practical experience may be more easily achieved with self-guided excursions (Holgersen, 2021). Finally, self-guided excursions are usually more flexible so that students can do them when it fits their schedule and the timing can more easily be adapted (e.g., to avoid bad weather conditions) than for large group excursions (Larsen et al., 2020; Thönnessen and Budke, 2021).

The results of studies that have evaluated different types of excursions are mixed (e.g., Costabile et al., 2008; Ruchter et al., 2010; Crawford et al., 2017). In a study with small groups of adult participants, the overall experience was similar for an excursion with a human guide, a mobile guide, and a brochure

as a guide (Ruchter et al., 2010). However, in another study, it was found that participants had more fun during the excursion when using a mobile phone guide (Crawford et al., 2017). Among other reasons, this may be due to the sense of modernity and innovation that such an excursion offers. Apart from the fun factor, mobile technologies also offer other benefits, such as GPS functionality for simplified orientation and navigation (Medzini et al., 2015) and a broad palette of options to present learning contents (Costabile et al., 2008; Jarvis and Dickie, 2010; Schneider and Schaal, 2018), such as pictures, videos, or audio recordings. Above all, the solutions to questions and exercises can be given directly so that the students immediately know whether they solved an exercise correctly or need to revise their solution. Another advantage is that no reports need to be written and graded after the excursion. The workload for instructors is, thus, not directly tied to the number of students. In other words, for excursions that are visited alone, in pairs, or in small groups, the participation of individuals increases, but the workload for instructors does not increase considerably. Once the rather time-intensive implementation of an excursion is done, the required efforts for running the excursion may get smaller with each realization (Kingston et al., 2012; Thönnessen and Budke, 2021).

However, preparing a self-guided excursion and carrying out such an excursion involves several challenges. Because the instructor is not present in person during the excursion and thus cannot support the students in their learning process, the contents of the self-guided excursion need to be clear and well-designed (Schultz and DeMers, 2020). The area where the excursion takes place needs to be known even better than in the normal case (Krakowka, 2012) because one cannot react to special circumstances, such as potentially dangerous locations, or adjust the route after the students have started the excursion. Therefore, the descriptions and instructions given to the students need to be clear and well thought through. As mentioned earlier, smartphones provide valuable tools that can overcome (some of) these challenges, and thanks to the availability of these devices among students, these tools can be brought into the curriculum without a major logistical challenge (Medzini et al., 2015).

We have used a self-guided excursion based on a smartphone app in an introductory Hydrology and Climatology course at the University of Zurich. Our one-day excursion focuses on water in the city of Zurich. As the development of the excursion had started just before the beginning of the Covid-19 pandemic, we were able to provide the first-year students in Geography and Earth System Sciences at the University of Zurich with a replacement for the usual large group excursion when our university switched completely to online teaching in spring 2020. Based on the students' feedback, we made a few adjustments before carrying out the excursion again in spring 2021.

This paper aims to describe and evaluate the self-guided excursion. First, we describe how the contents of the excursion were implemented in the scavenger hunt application (app) "Actionbound" (www.actionbound.com). Afterwards, we

TABLE 1 | Overview of the topics covered in the Water in the city of Zurich excursion and example activities. The section and number indicate the section (A–D) of the excursion and the stop number.

Subject area	Topic	Activities	Section and number
Water in lakes and rivers	Discharge estimation	Estimation of the discharge in a small creek using the stick method and the Manning-Strickler formula	A2
	Temporary streams	Determination of the state of a temporary (i.e., intermittent) stream (flowing, standing water, dry)	A3
	Lake	Read information text and graphics about the temperature- and water level dynamics in a lake during different seasons	B1
	Hydrometry	Read information text, pictures and graphics about hydrometric methods, compare measurements to direct estimate of the discharge	D2
	Characteristics of different rivers	Comparison of two rivers (discharge, specific discharge, sediment concentration, color) at their confluence	D4
Natural hazards	Sediment transport	Explanation of an underground sediment retention basin	A1
	Flood protection measures I	Watch a video about flood risks and flood protection measures; case study: How would the students react to a specific situation if they were responsible?	B4
	Flood protection measures II	Listen to a radio report about a bridge that has to be replaced to improve flood protection	C4
Sanitation	Emergency wells	Visit of an emergency well, read about their importance for the city, drink the water and smell the taste the difference in the water from different sources	C2
	Groundwater and drinking water	Walk along the "water way" and read the information boards in the area where the city has a groundwater well field and around the water and wastewater treatment facilities, answer questions	D1
History	Canal as part of the city defense system	Walk along the canal and read about its history and characteristics	B2
	Perception of rivers in a city	Listen to a literary text about how an inhabitant of the city perceives the river and how the city and the river affect each other	B5
	History of wells	Visit different wells and fountains and read about their history	C1
	Roman bath culture	Visit an archeological site with information boards about Roman baths	C3
Economy	Fish ladder	Look at pictures and read text about different types of fish ladders; estimation of the length of the largest possible fish that can use the fish ladder	B3
	Hydropower plant	Visit of a hydropower plant, read information about its history, its economic importance, and its influence on the natural ecosystem	D3

evaluate the experiences of the students based on a survey held directly after the excursion, and another one held in fall 2021 (i.e., several months to more than 1 year after the excursion) about what they remembered from the excursion and its contents. Finally, we discuss the advantages and disadvantages of this kind of excursion and provide tips and tricks for implementing a similar excursion in other places. Because every city and excursion is different, our excursion can only serve as an example. We give examples of what could be included in an excursion about water in a city and hope that this description may inspire other university teachers to develop smartphone-based self-guided excursions as well.
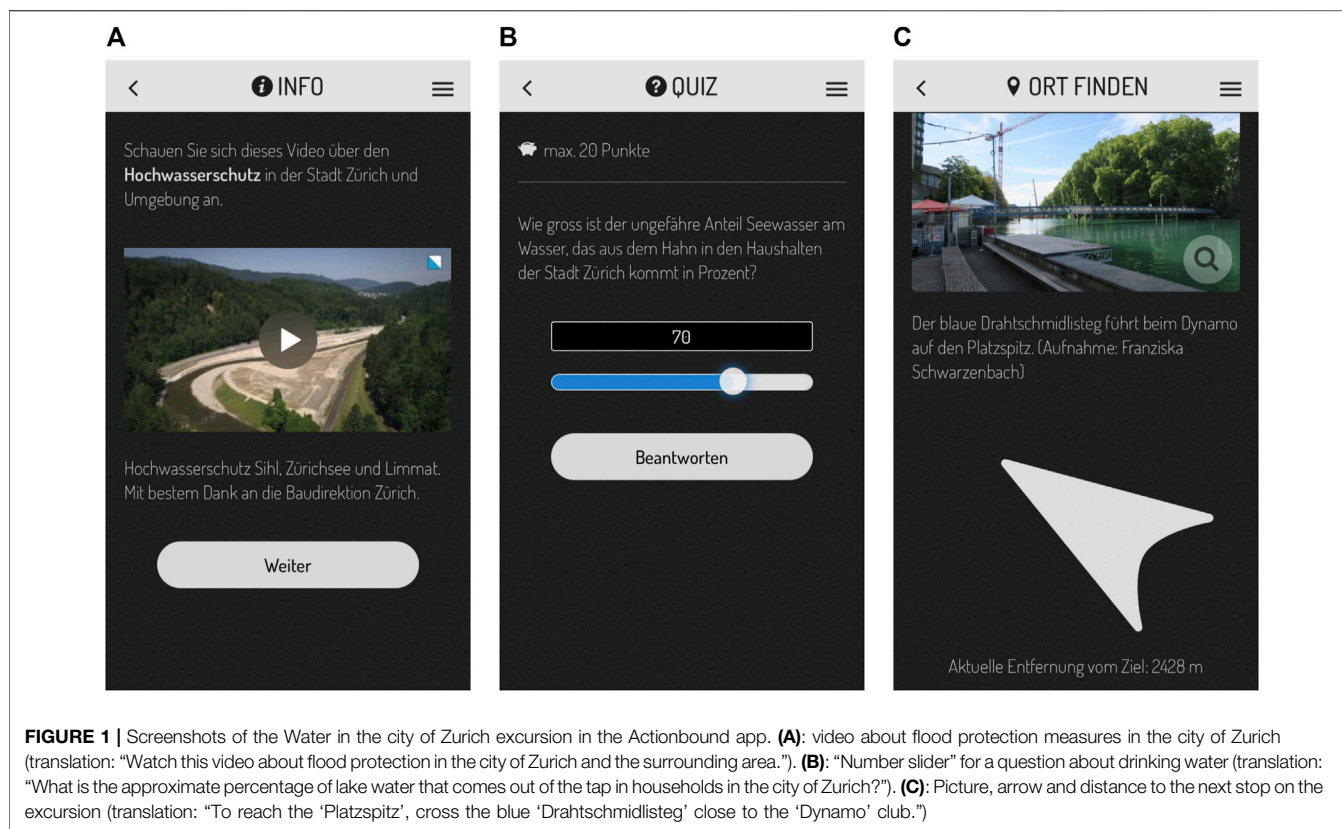
DESCRIPTION

Background of the Excursion

The excursion about water in the city of Zurich, Switzerland, is part of the course Physical Geography II, Introduction to Hydrology and Climatology, at the Department of Geography at the University of Zurich. The course is a compulsory course for Bachelor students in Geography and Earth System Sciences. Most students take the course in their second semester at university. The excursion is visited by about 150 students each year. The teaching language is German; thus, the language of the excursion also German. While most students taking the course are native speakers, German is the second or third language for some students; students from the Italian-speaking canton of Ticino form the largest group of non-native German speakers.

Zurich is the largest city in Switzerland, with 430,000 inhabitants and more than a million people living in the larger urban area (agglomeration). The excursion was divided into four sections (A–D), each covering one geographic region of the city. We aimed to have a balanced selection of topics to show the different facets of water and its use, while ensuring that they were all somehow connected. Thus, in each section, the excursion passed by natural watercourses and human-made water structures (**Table 1**). Each section consisted of multiple stops, where the students were asked to answer questions or do some other activity. All stops within a section were located reasonably close together, so that they could be visited by foot. The different sections could be reached by foot, public transport or bike. The entire excursion (i.e., all four sections) could be completed within 1 day. Students were allowed to choose with which section they wanted to start, and had to complete the other sections in

FIGURE 1 | Screenshots of the Water in the city of Zurich excursion in the Actionbound app. **(A)**: video about flood protection measures in the city of Zurich (translation: "Watch this video about flood protection in the city of Zurich and the surrounding area."). **(B)**: "Number slider" for a question about drinking water (translation: "What is the approximate percentage of lake water that comes out of the tap in households in the city of Zurich?"). **(C)**: Picture, arrow and distance to the next stop on the excursion (translation: "To reach the 'Platzspitz', cross the blue 'Drahtschmidlisteg' close to the 'Dynamo' club.")

alphabetic order to avoid large groups of students visiting the excursion together.

There was already a self-guided excursion about water in the city of Zurich, which we used as the starting point for the new smartphone-guided excursion. For this "pen and paper" version of the excursion, the students obtained a workbook with information, directions and maps, and questions and assignments. The students afterwards handed in a report that contained the answers to the questions and assignments, which was then graded. Similar to other studies (Moore et al., 2011), we found it very useful to use an existing excursion or template for the development of the self-guided excursion. The use of this existing excursion as a starting point mainly reduced the amount of time that was needed to identify interesting places in the city that could be visited by the students. However, we had to make many changes to the structure of the excursion, mainly to take advantage of the new possibilities provided by using smartphones, e.g., the inclusion of audio and video material. The students no longer had to write a report but received immediate feedback on their answers, which meant that the questions and tasks had to be restructured. Compared to a "pen and paper" excursion, an excursion with a smartphone does not provide suitable options to include questions that require essay-like answers. The small screen of a smartphone is also not ideal for providing a lot of text. We tried to keep the texts short, but also created an additional pdf file containing all the longer texts included in the excursion. This allows students to read the longer texts already before they start the excursion, or

they can make print-outs and read the texts on paper during the excursion.

Implementation of the Excursion

After reviewing several smartphone options, we decided to use "Actionbound" for the implementation of the excursion because it offered a complete package and, therefore, was a time-efficient and convenient solution compared to designing something on our own [as was, for example, done by Pang and Weatherley (2016)]. Actionbound is developed by Actionbound GmbH in Berlin. Actionbound offers an online user interface to create indoor and outdoor scavenger hunts, called "bounds". Implementing a smartphone-based excursion using Actionbound does not require any programming skills. The online user interface is designed to be intuitive and interactive. After half an hour of playing around, all the functionalities can easily be used. There is a user forum in which many questions have already been answered. New questions are usually answered by the development team within a few hours.

Actionbound offers different types of licenses. The lecturer license fits our needs best. For a flat rate of 99 Euros per year, an unlimited number of bounds can be created. These bounds can be used by all students visiting a course from one lecturer. The use of the app is free for the students. There are also other solutions, for example, faculty licenses or licenses that allow a bound to be used a certain number of times, e.g., for outreach events. Actionbound can be tested for free for 14 days. The use of Actionbound for private purposes is free.

TABLE 2 | Media types that can be used in the excursion and examples from the Water in the city of Zurich excursion.

Media	Examples
(Short) texts	– History of different wells – History, use and environmental impact of the hydropower plant – Text about the regulation of the water level of the lake
Pictures and graphics	– Pictures of high flow or low flow situations of a river – Photos of an exceptionally cold period when the lake was frozen – Pictures of the underground sediment collector – Visualization of the "positive rheotaxis" (of fish and how that can be used for fish ladders) – Graph showing the stage-discharge-relationship of the Limmat at the gauging station in Zurich
Videos	– Video explaining the stick method for discharge estimation – Video about the flood risk in Zurich and the measures taken to protect the city from these risks – Video of a discharge measurement in the Limmat using a current meter
Audio	– Short audiobook of a literary text about the Sihl, the wilder river in Zurich – Radio report on the renewal of a bridge as part of the flood protection measures
Information boards elsewhere	– Information boards from the local authorities about the drinking water supply – Information boards from the local authorities about the Roman baths
Objects in the city	– Physical staff gauge in the Limmat and the Schanzengraben to read the water level – Fish ladder

TABLE 3 | Question types and examples from the Water in the city of Zurich excursion.

Question type	Examples of questions
Multiple choice	Multiple correct answers: – Which flood protection measures were mentioned in the video? – What factors contribute to the exceptionally high flood risk for Zurich? One correct answer: – What is the reason for the higher specific mean discharge of the Limmat than the Sihl? – What is the mean residence time of the water in the lake of Zurich?
Enter free text	– What is the name of the street that follows the route of the former Sihl channel? – How many lake waterworks does Zurich have?
Number slider	– How much bigger is the environmental burden of 1 L of bottled water compared to 1 L of tap water? – Under the assumption that the fish ladder in the Schanzengraben meets the legal requirements for its length, how long (in cm) is the longest fish that you can expect here?
Sort list	– Put the four pictures showing the temperature distribution in the lake in the following order: winter—spring—summer—autumn.
Survey	– If you were responsible for the safety of the city of Zurich, how would you react to the flood risk in May 2013? – Which flow class did you observe in the temporary stream?
Upload picture	– Upload a picture showing where you estimated the discharge using the stick method. – Upload a selfie with the emergency well. If you don't feel comfortable with uploading a selfie, take a picture of your shoe.

Students can access a bound (i.e., the excursion) with the app using a QR code or the title of the bound. The full bound can be downloaded at once, so that cellphone coverage is not necessary during the excursion. The app then guides the students to the places of interest, provides information in various formats, and gives assignments to complete and questions to answer (see screenshots in **Figure 1**). The students collect points by finding the right locations, answering questions correctly, and completing assignments. The results are uploaded as soon as a student has finished the excursion. The user interface of the instructors then shows the answers to the questions, the files that were uploaded by the student, the number of points obtained for each step or question, and the time used to complete each individual step and the complete bound. In our case, the students needed to complete the bound and obtain a minimum number of points to pass the excursion. There was no competition among the students regarding the number of points obtained, but this element can potentially be used to motivate students. It has been shown that, in general, students tend to respond well to some added pressure with a point collection system (Krakowka, 2012).

The locations that the students need to visit during the excursion are stored in the bound. This can be done by either clicking on the corresponding point on a map or by entering

TABLE 4 | Time investment for the development of the smartphone-based self-guided excursion.

Task	Approximate time used
Implementation of the original structure of the "pen and paper" excursion into Actionbound	8 h
Updating the excursion material, search for additional information	20 h
Re-structuring of the excursion, implementation of new contents, adjustments after feedback and tests	50 h
Test runs	20 h
Create information files for students	5 h
Communication with students, verification of student visits	15 h

the coordinates. These components serve as a guideline throughout the entire excursion: all the sites that the students should visit are stored this way. To make it easier for the students to find the correct locations, we also added pictures that indicated the correct way and the points of interest. These pictures were meant to be helpful, especially for students who had issues with the GPS on their smartphones.

The bound can be filled with different media, such as texts, pictures, videos, or audio recordings (**Table 2**). These can be uploaded in the most common formats (e.g., jpeg, png, mp3, mp4) to a media library. Thus, no special file formats are needed, which was the case some 10 years ago (Moore et al., 2011). In addition to providing information and waypoints, there are many possibilities to design quizzes and exercises for the students (see examples in **Table 3**). The responses of the students were automatically graded, except for the survey questions or the upload of a picture (because there is no right or wrong answer in these cases). To keep the students motivated, the level of difficulty was chosen in such a way that the questions were not trivial but also not too difficult. As a result, the students could answer the questions correctly if they tried to solve them conscientiously and, thus, collect many points. In multiple-choice type questions, points were given for partially correct answers as well. When entering a free text, different ways of expressing the answer were accepted, and for the number slider, we gave partial points for values that were close to the correct one. To improve the learning experience, the correct answer was shown directly after the question if it was not answered correctly. For more complex concepts (e.g., the influence of changes in the riverbed on the stage-discharge-relationship), an additional explanation that included an explanatory graphic was shown if the question was not answered correctly.

Realization of the Excursion

Table 4 gives an overview of the approximate time investment for the realization of the self-guided excursion. This started with the decision to use Actionbound and ended with the implementation of the feedback from the students after they visited the excursion. Of course, the time required strongly depends on how much time needs to be invested in finding interesting sites (and thus how familiar someone is already with the area), as well as the scope and length of the excursion, and the time required to get to the start of the excursion for the test runs. Implementation of the structure of the original pen and paper-based excursion was done within one workday. Implementing the new contents and the new structure took the most time.
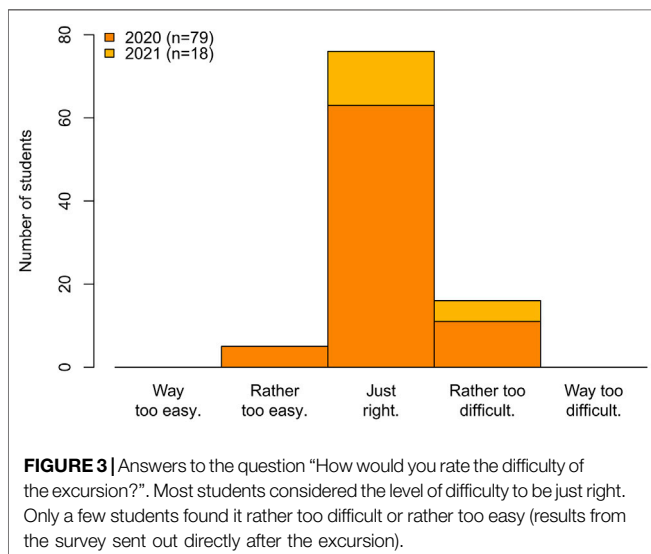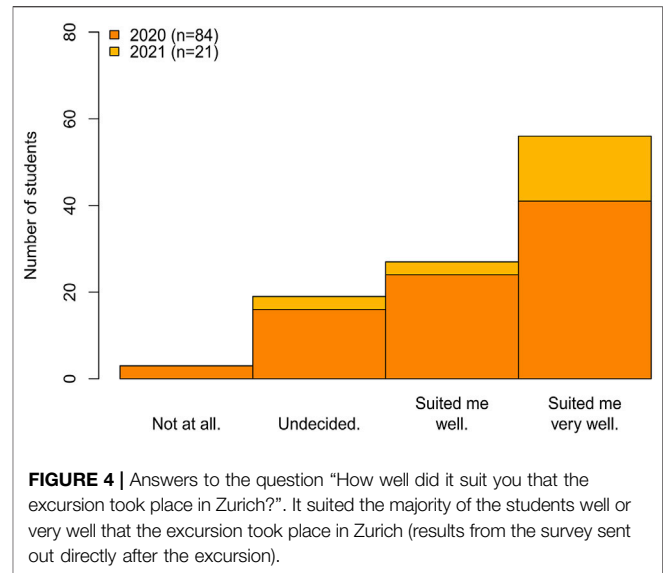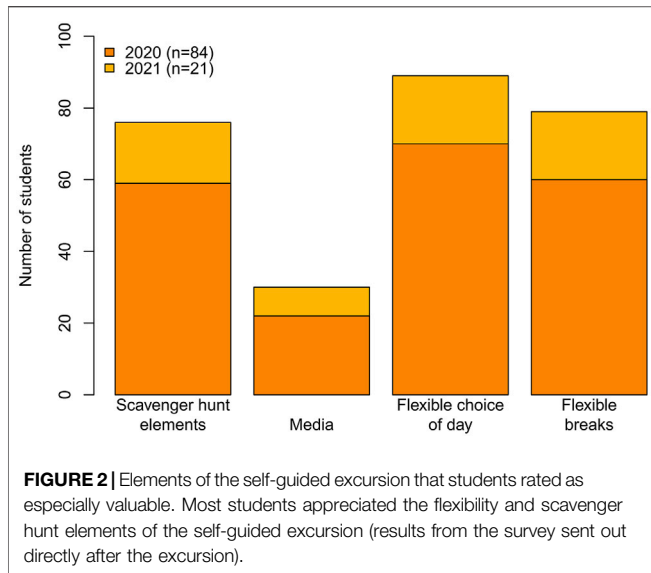
Before the students went on the excursion, we tested the different sections several times to ensure that the stored locations were correct and everything worked. These tests were also valuable for taking the pictures that were used as descriptions or illustrations. Additionally, one student visited the excursion before the other students and provided us with detailed feedback and comments that we implemented before the entire class took the excursion.

Although the primary time commitment was the initial implementation, some effort was still required during the excursion time to ensure that everything worked out fine and that the students received help if they faced difficulties. We tried to be available for the students *via* e-mail and provide them with instant help and answers when they had problems with the app or the GPS on their smartphone.

As mentioned before, the students collected points during the excursion by passing by specific locations, correctly answering the questions, or completing certain assignments, and needed to collect a minimum number of points to pass the excursion. We checked the number of points that each student collected, as well as the time that it took them to complete the bound to ensure that they visited the entire self-guided excursion. In the first year, it was rather time-consuming to check if all the students completed the excursion. For the second year, extensive testing and attendance behind the scenes were not needed to the same extent, and many tasks could be delegated to student assistants. Thus, the effort required from the instructors in this second year was significantly smaller than for the traditional group excursion, especially because the group excursion was usually repeated multiple times due to the large number of students in the course. We assume that we can continue to use the self-guided excursion in the coming years without significant additional efforts. Some minor updates and changes as well as double-checking that all points can still be reached may be required to keep the excursion up to date. If this is done on a regular basis, we see no reason why the excursion would be outdated after a few years.

EVALUATION

We gave the students the option to provide feedback after each section of the excursion and asked them to complete a survey about their experiences after they had completed the entire excursion. We received answers from 86 of the 162 students who completed the excursion in 2020 (53%), but after the 2021 excursion we only received answers from 21 of the 136 students

FIGURE 2 | Elements of the self-guided excursion that students rated as especially valuable. Most students appreciated the flexibility and scavenger hunt elements of the self-guided excursion (results from the survey sent directly after the excursion).

FIGURE 4 | Answers to the question "How well did it suit you that the excursion took place in Zurich?". It suited the majority of the students well or very well that the excursion took place in Zurich (results from the survey sent out directly after the excursion).

FIGURE 3 | Answers to the question "How would you rate the difficulty of the excursion?". Most students considered the level of difficulty to be just right. Only a few students found it rather too difficult or rather too easy (results from the survey sent out directly after the excursion).

who completed the excursion (15%). As we were more reliant on the students' feedback in the first year, we had a raffle (free cinema tickets) for helpful feedback, which we did not have in the second year. This may explain a large part of the difference in response rates for the 2 years. A follow-up survey was sent out in fall 2021 (i.e., five, respectively, 17 months after the excursion), which was answered by 92 students: 43 students did the excursion in 2020 and the other 49 in 2021. However, some of the students did not answer all the questions. Because only a small portion of the students filled in the survey, the answers are not fully representative but provide more of an indication of how the excursion was perceived. The information from these surveys was nevertheless valuable to improve the excursion. For instance, the additional pdf file containing all the longer texts of the excursion and the additional pictures showing the path that the students need to follow originated from the students' feedback. The option
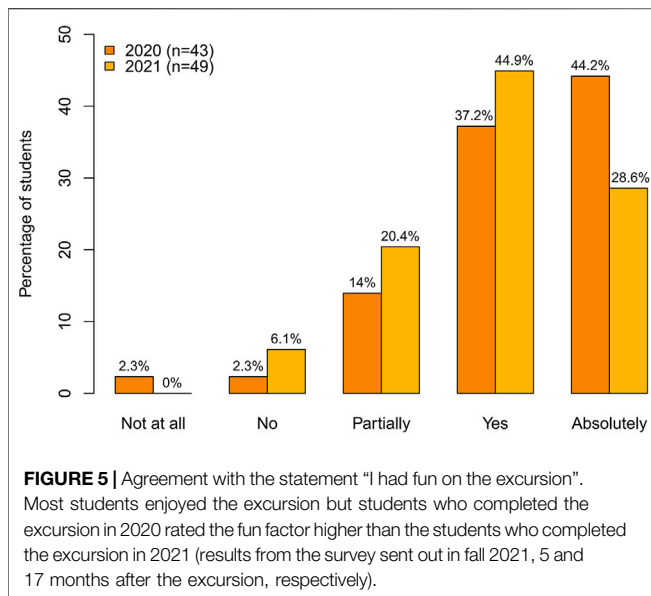
to upload a photo of the visited site if the GPS did not work as an alternative for getting the points to find the site was also implemented after the first use of the excursion.

Impressions of the Students Directly After the Excursion

Directly after the excursion, most students indicated that they appreciated the flexibility that a self-guided excursion offers (**Figure 2**). The flexible choice of the excursion day was rated even higher than the flexibility to take breaks during the excursion. Several students mentioned in the open comments that they appreciated the ability to choose the speed of the excursion on their own. Thus, the flexibility during the day seems to have been very valuable too. Most of the students also indicated that they liked the scavenger hunt elements that the self-guided excursion offers because they made the day more fun. The different types of media that were included in the excursion were not mentioned as one of the most valuable features, but they were also not considered a negative aspect. In 2020, 87% of the students who completed the survey thought that the different question types made the excursion varied and did not think that certain question types were not so suitable; 95% of the students answering this question in 2021 shared this opinion.

Most students indicated that the level of difficulty was appropriate and that they were neither over- nor under- challenged (**Figure 3**). About a sixth of the students had some issues with understanding the contents or solving specific tasks and therefore rated the excursion as rather too difficult. A few students would have wished for some more challenging exercises and found the excursion contents rather too easy for the level of studies. None of the students considered the level of difficulty to be completely off.

Most students appreciated that the excursion took place in the city of Zurich, where many of them live (**Figure 4**). They mentioned that the travel distances, and thus travel time and
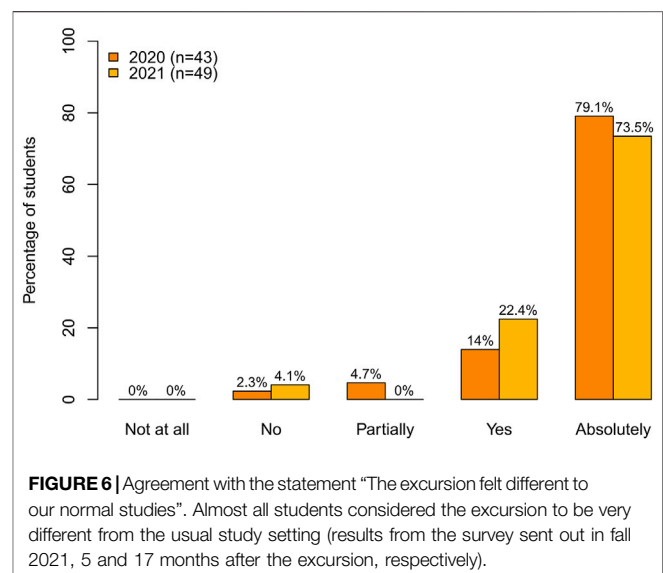
FIGURE 5 | Agreement with the statement "I had fun on the excursion". Most students enjoyed the excursion but students who completed the excursion in 2020 rated the fun factor higher than the students who completed the excursion in 2021 (results from the survey sent out in fall 2021, 5 and 17 months after the excursion, respectively).

costs, were kept low this way and that they liked getting to know the city where they are studying better, and in a different way. They frequently mentioned that they had been living in or around Zurich for many years but never realized all the different facets of water in their city and, thus, enjoyed this new focus. They also appreciated that—thanks to the relatively short distances between the different stops, more environmentally friendly modes of travel (i.e., public transport, bicycle, or walking) could be chosen than the bus for a typical group excursion. However, despite these advantages of an excursion in the city of their university, some students mentioned that they would have preferred an excursion to a mountainous area or a more remote area without so many people and noises. This was mainly mentioned by students who did the excursion in 2020 when an excursion to the Alps was planned and announced at the beginning of the term but had to be cancelled. In 2021, this alternative was never mentioned to the students.

The main criticism from the students was that the excursion was too long or that it took them more time than the 6–7 h that we had assumed. However, we calculated the average time that students needed to complete the excursion in 2021, and it was 6 h (standard deviation: 1.4 h), including breaks. The additional comments to this question indicate that this impression was related to the walking distances. Many students commented that walking through the city for several hours on a hot summer day or while it was raining was too long. Students perceived the walking distances to be exhausting and were potentially not adequately prepared, e.g., they were not wearing appropriate shoes or did not expect any physical effort because the excursion took place in a city. If public transport is used where it is recommended, the total walking distance is ~11 km. If public transport is only used for the longer distances between the four sections, the walking distance is almost 16 km. Related to the duration of the excursion, some students mentioned that the battery consumption of the app was too high or that they forgot to bring a power bank. A handful of students also mentioned that their GPS did not work.

The students also mentioned that they could not socialize with their classmates or get to know more people during the excursion. We also see the lack of a social aspect as a downside of a self-guided excursion. In the first year, we requested that the students complete the excursion on their own to ensure safe distances with regard to Covid. We did not say that the students have to do the excursion on their own in the second year but they still had to sign up for a time window (to keep potential group sizes small). As a result, many students visited the excursion in pairs or small groups in 2021. They mentioned in their feedback that they enjoyed solving problems together, helping each other when difficulties occurred, discussing their ideas and impressions, and having fun during the day.

Impressions of the Students Several Months After the Excursion

The survey that was completed about 1.5 years after the excursion suggests that the students who took the excursion in 2020 had a lot of fun, even though many of them visited the excursion alone. The students who took the excursion in 2021 also enjoyed the excursion, but overall did not rate the fun aspect quite as high (**Figure 5**) when answering the same survey about 5 months after completing the excursion. However, in the surveys completed directly after the excursion, the percentage of students considering the excursion fun or very fun was similar (about 77%; but note that far fewer students returned the survey in 2021 than in 2020). The selfies that we asked the students to upload at one of the stops included a lot of smiling faces in 2020 and 2021, which may also indicate that the students had fun on the excursion in both years. The evaluations of the course of which the excursion is a part were better in 2020 than for any other year before. This suggests that many students valued the extra efforts of the instructors during the unexpected situation and that they were happy that the excursion was not cancelled completely but that an alternative smartphone-guided excursion

FIGURE 6 | Agreement with the statement "The excursion felt different to our normal studies". Almost all students considered the excursion to be very different from the usual study setting (results from the survey sent out in fall 2021, 5 and 17 months after the excursion, respectively).

was offered. Alternatively, it could be that after the lock-down in 2020, the students were very happy to be outside again.

For all the other questions, such as how different the excursion felt to their normal studies (**Figure 6**), if the students found the smartphone-guided excursion innovative, if they felt that they learned something during the excursion, and questions regarding the organization of the excursion, there were no clear differences between the responses of the students from the 2 years. Overall, the feedback was very positive in both years. There was also no clear preference for one excursion type: 21% of all the students who answered the survey recommended a self-guided excursion instead of a group excursion for other courses as well, 38% were undecided between a self-guided excursion and a traditional excursion, 25% would rate a traditional excursion slightly higher if they had the choice, and 16% would prefer a traditional excursion over a self-guided excursion.

Potential for Learning

Because we never held the "Water in the City of Zurich" excursion as a group excursion, we cannot compare how much the students learned on the self-guided excursion to what they learned on a traditional excursion. However, from the survey that we asked the students to fill out several months after the excursion, we can still make a statement about the potential for learning during the self-guided excursion. Based on the answers to the question about what comes to their mind first when they think about the excursion (two exemplary answers shown below), we can infer that many students thought that they learned something or that the excursion was informative and diverse:

– "*neue Einblicke in bekanntes Gebiet, heisser Tag, anstrengend, aber lehrreich*" ("new insights into a known area, a hot day, exhausting, but informative")
– "*Ich fand sie* (die Exkursion) *super spannend. Zum einen lernte ich viel über Wasser aber mit den Spaziergängen auch viel über die Stadt Zürich.*" ["I found it (the excursion) super-interesting. On the one hand I learned a lot about water but with the walks also a lot about the city of Zurich."]

About 55% of the students said they could remember the contents equally well or even better than for a typical group excursion. More than 75% of the students answered that they still think about the contents of the excursion when they walk through the city and more than 60% already told someone else about something that they learned during the excursion. From the comments, it appears that the exceptionalities taught during the excursion were most firmly anchored in the students' memories. For example, the students seem to best remember the existence of the more than 80 emergency wells that deliver fresh water to the city in case of an emergency in the water supply system, and that the river Sihl flows through the main train station and that this increases the flood risk considerably. The answers to the specific knowledge questions that we asked in the survey several months after the excursion reflect the same. Questions about specific facts were mainly answered correctly, while the quality of the answers for more technical questions

differed a lot. For example, the question about the purpose of the enrichment basins in the groundwater well field was only answered correctly by 30% of the students, while 20% chose one of the two wrong answers and 50% said that they did not remember the answer to this question. Even though the hydrological details were forgotten, the students indicated that they remembered the stops where they learned these contents very well and thought about the excursion when they passed by these places at a later time.

DISCUSSION

Benefits of Self-Guided Excursions

Mobile technologies can be useful in learning settings and support the conceptualization of new content and scaffolding processes (Brickell and Herrington, 2006; Lai et al., 2007). A smartphone based self-guided excursion combines a field trip, a teaching method that is generally liked by students (Krakowka, 2012), with innovative smartphone applications for learning, which are also highly appreciated by students (Kingston et al., 2012). Our results confirm these previous findings and show that the students enjoyed visiting the self-guided excursion and the scavenger hunt elements and gamification aspects because they make learning more fun. We see a lot of advantages of self-guided excursions, especially for large student groups. The students are no longer passive listeners but need to be engaged and complete individual assignments, which may help them to understand the concepts taught during the excursion. The students receive immediate feedback and there is no grading of reports. One could argue that with increasing group size, the advantages of a self-guided excursion outweigh the disadvantages, such as the lack of the group experience and the lack of possibilities to directly ask questions. An excursion with a small group of students and an expert may offer better learning opportunities than a self-guided excursion using smartphones due to the intensive student-teacher interaction. However, this is for many courses not feasible and the average student-teacher interaction during traditional large group excursions is marginal. For these courses, a self-guided excursion using a smartphone may improve individual learning. However, more research about the effectiveness of excursions using mobile technologies compared to that of traditional group excursions is needed.

Another big advantage of a self-guided excursion compared to a traditional group excursion is the flexibility and independence in terms of schedule. Because the excursion is individual, students can more easily fit the excursion in their schedule and if they cannot join on the day that they planned to do it (e.g., due to illness), it is much easier to complete the excursion on a different day. This flexibility was highly appreciated by the students (**Figure 2**) and agrees with the experiences of other university teachers (e.g., Wissmann, 2013). One can assume that the demand for flexible and individual approaches may be even higher in the post-pandemic world because students became used to a flexible learning environment (e.g., asynchronous lectures) during the pandemic. Aside from the flexibility for

the students, the organization of a self-guided excursion is also more flexible for the instructors because they do not need to reserve a particular timeslot to accompany the excursion.

Benefits of an Excursion in the City

Our excursion is certainly not the first physical geography or geosciences excursion to take place in a city. There are, for example, geology excursions that guide students to different buildings to look at different rocks. However, most excursions in physical geography and geosciences take place in mountainous areas or other places where it is possible to observe natural processes or human-nature interactions. Students who are used to being outdoors, e.g., because they are used to go camping or hiking, have an advantage over students for which this terrain is unfamiliar. It also means that students need to have appropriate gear and a certain level of fitness to be able to participate in these types of excursions. This requirement for gear and outdoor experience contributes to the geosciences not being inclusive (e.g., Wechsler et al., 2005; Huntoon and Lane, 2007; Gates et al., 2019). A smartphone-based excursion taking place in a city can reduce these inequalities and thus help to make excursions more inclusive.

It is also much easier to implement a self-guided excursion in a city. Compared to a remote area, there are usually fewer safety concerns (although new issues may arise, such as risks due to traffic or crime). A well-connected and central city is easier to reach than remote sites. This applies not only to the students but also for the test runs that need to be done during the development of the excursion. Furthermore, a diverse range of topics may be found within a shorter distance in a city than in a natural area. Additionally, one can expect a better and more continuous cellphone reception in a city, which is valuable for safety reasons and to look up additional information (the full bound can be downloaded in advance).

Our decision for an excursion in the city of the university meant that many of the students had already been to some of the places of the excursion and that it is likely that they will pass by these places again after the excursion. Our surveys suggest that students do indeed return to these places and that they are then reminded about the excursion and its contents. Many students also used this as a teaching moment and explained what they learned to others. In other words, there may be long-time learning beyond the excursion day itself. Moore, Kerr and Hadgraft (2011) showed that it is valuable to revisit sites again after the excursion. It has been suggested that by already being familiar with some of the sites, the "novelty space" is reduced and the working memory can focus on the new content (Orion and Hofstein, 1994), so that it is easier to assimilate new information than in a completely new environment.

Recommendations for Developing a Smartphone-Based Self-Guided Excursion

Self-guided smartphone excursions are a valuable tool in geography education and make use of the new opportunities that mobile technologies offer. Even if a traditional group excursion is possible, this new kind of excursion should be

considered as well. If for some reason, a group excursion must be cancelled or is no longer feasible, e.g., because the student numbers are too high, a self-guided excursion should be considered instead of cancelling the excursion completely. We can recommend such an excursion in the city of the university or, more generally, in a place more unusual for an excursion in physical geography. Students appreciate this kind of replacement, especially if they can complete the excursion in pairs or small groups. In contrast, the replacement of the excursion with an online assignment in a similar case was not liked by the students (Gašparová and Kyseľová, 2020). When repeating the excursion for multiple years, the efforts required to implement the excursion in the beginning (**Table 4**) are small.

We recommend that instructors who consider developing a similar excursion plan enough time for preparation and, if possible, to build the self-guided smartphone excursion based on previous material, such as an existing excursion or route along interesting spots. We also recommend using various media to keep the excursion as interesting as possible. Question types should be varied as much as possible as well to avoid different tasks getting boring. However, not too much typing should be required to answer the questions. It will be frustrating for the students if a correct answer is graded wrong because of an auto-correction algorithm (which is often the case for jargon) or typos that are not recognized as typos by the mobile application.

There are different reasons to keep the level of difficulty rather low. First, students will be more motivated when they realize that they can solve the questions (and vice versa get frustrated if they answer too many questions wrong). Furthermore, there is no possibility to ask questions directly if something is unclear. An appropriate (or somewhat low) level of difficulty reduces the risk that students are lost and struggle to understand any of the contents during the excursion. We considered a large range of answers correct, and many answers could be found directly on information boards or in the media that were included in the bound, so that it was rather easy to collect points on the excursion. The main goal of using the app was to guide the students along interesting places in the city and not to create a test or let them answer challenging questions. The majority of the students considered this level of difficulty appropriate (**Figure 3**). Therefore, we can assume that the excursion was still not perceived as trivial. Additionally, the survey results showed that it is not the more complicated details that students remembered after a few months, but the interesting facts. To reach the ultimate goal that students remember as much as possible from the excursion, it is thus advantageous to also include relatively easy but interesting (or surprising) content.

Since our target group are first-year undergraduate students, it was acceptable to include very few quantitative and higher-level questions in the excursion. For the estimation of the different components in the Manning-Strickler formula, we asked the students to enter the intermediate steps of the calculation as an answer to a free text question. We considered all estimates within a reasonable range as correct and provided the students with some guidance if they needed to adjust their numbers. The students had to enter the calculated discharge also as a free text question. This answer had to be within a reasonable range to be

counted as correct. For upper-level or graduate-level classes, more quantitative questions and demanding tasks may be required. One option to include these types of assignments is to ask the students to solve a certain task on a piece of paper (e.g., to write down their calculations or to make a sketch (e.g., a geologic map)) and have them upload a picture of it in the app. Alternatively, one can also ask for a text, a video or an audio submission. Automatic grading is not possible in these cases and the instructor will thus have to review the solution after the excursion is finished. If this is only the case for a few assignments, and the number of students is not too high (which is usually the case in graduate-level courses), this may be a reasonable workaround to not being able to grade a question directly in the app.

The students' feedback showed that if an excursion takes too long or is longer than expected, the fun aspects of the smartphone-based excursion fades. Even though the self-guided excursion does not take as long as the previous full-day group excursion (6 instead of 10–12 h), it seemed that for some students this type of excursion feels more exhausting than a group excursion. This may be due to the higher effort that is required of the students. On a self-guided excursion, students are mentally engaged the entire time. In contrast, group excursions often include more downtime (such as during transport, walking, waiting for other group members to arrive, etc.). To avoid the excursion taking longer than expected, we suggest to provide the students with a schedule that assumes a slow pace, so that they will be happy if they are faster than expected and not frustrated that it takes them longer than planned. To ensure that students are mentally and physically prepared for the excursion (e.g., wear appropriate shoes and clothing), the duration of the excursion and the walking distances should be announced clearly. To avoid the drop in the fun-factor (and probably also engagement), a self-guided excursion can also be split into several parts that can be visited on different days (as suggested by Wissmann (2013)).

We recommend sending students in small teams because no direct teacher-student interaction is possible on a self-guided excursion. This way, students have the possibility to discuss the contents with each other and to help each other to understand the assignments. Furthermore, students seem to enjoy being on the road with each other. Small groups of two to four students seem to be a good compromise between individual engagement and the social aspect of an excursion.

There are more options to cheat on a self-guided excursion than on a traditional group excursion that is not graded and where you are either present or absent. Technically, one student could visit the excursion with the smartphones of several other students. Moreover, there are ways to pretend that a smartphone is in a certain location, and thus all stops could be "visited" while sitting at home in front of a screen. Although these risks cannot be eliminated entirely, they are reduced if students are asked to upload a picture at some point during the excursion. As mentioned before, we checked the time that the students needed to complete the excursion and the points they achieved, prior to giving them the mark that they passed the excursion. These checks are easily possible with tools like Actionbound. We did not find any indication that cheating was a problem. As excursions are generally well-liked by students, one can expect that most students will not try to cheat in this part of a course.

Finally, we recommend to prepare a document with all the information that the students require before they visit the excursion, such as clear instructions on what they can expect, an indication of the time needed to complete the excursion, walking distances, as well as the equipment needed on the excursion and technical preparations (e.g., to download the required app, the bound, and further materials). It is also helpful to tell the students to take a power bank (or charger) with them as they are heavily dependent on their smartphones during the excursion. Moreover, factors reducing the experience, such as long texts that are hard to read on a small display or due to sunlight on the screen, or a non-functioning GPS should be reduced as far as possible, or alternatives should be given (Ruchter et al., 2010; Kingston et al., 2012).

CONCLUDING REMARKS

Smartphone-based self-guided excursions provide an interesting and useful new opportunity to organize excursions in university teaching. With higher student numbers and limited resources and an increasing number of possibilities on how to use smartphones for learning, smartphone-based excursions may gain importance in the coming years. Students seem to like the new way of exploring their surroundings and learning at their own pace. Furthermore, this kind of excursion offers excellent opportunities for direct feedback, which makes learning more effective and reduces the efforts of instructors to grade excursion reports. Compared to a traditional large group excursion, where there are always students standing in the back and cannot hear what the instructor is saying, self-guided excursions bring learning down to an individual level and potentially increase the mental engagement of each student. In addition, the students appreciate the flexibility that it provides during the day and the possibility to choose an excursion day that fits their schedule.

We hope that the excursion about water in the city of Zurich presented in this paper inspires other instructors to create similar excursions. New self-guided excursions may help to curb the trend of having fewer and fewer excursions in geography and geoscience-related study programmes. However, not every traditional excursion can be replaced by a self-guided smartphone excursion. For example, dangerous sites such as glaciers cannot be explored using a smartphone excursion. Thus, one should carefully consider suitable sites for a self-guided smartphone excursion. This may be an unconventional site that would not be visited during a traditional group excursion. Water in the city can be an interesting topic for such an excursion because there are a lot of possible places to explore. If the chosen city is the hometown of the students or close to where they live, they are likely to pass by the places of the excursion again. They are then reminded about the contents of the excursion, and may also tell others about what they learned during the excursion.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

AUTHOR CONTRIBUTIONS

JS and HvM had the idea for the self-guided smartphone excursion and acquired the funding. FS implemented the excursion in Actionbound. HvM and JS tested the excursion and gave feedback for improvement. FS sent out the surveys to the students and analyzed the answers. FS wrote the first draft of the manuscript. All authors reviewed and edited the manuscript.

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