Mobile User Experience to Learn About Geology While Hiking: The Syros GeoPaths app

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ABSTRACT

This paper presents the design and field evaluation of Syros GeoPaths, a mobile app that has been developed to support visitors of the Syros GeoPark, so they learn about its geological significance while hiking in a protected area. Syros GeoPaths supports the user experience before, during, and after a hike following principles of calm design. Before the hike, the app informs hikers about the preparations needed and the characteristics of the paths. During the hike, the app helps users navigate the GeoPaths and points of interest, while presenting geological information in visual and audio descriptions. After the hike, the app offers certificates of achievements to visitors, based on statistics of the user behavior during the hike. The app has been developed in open technologies: Android and OpenStreetMaps. It fully operates without requiring data connection, since this is sometimes unavailable in this area. A field evaluation of the Syros GeoPaths mobile app has identified several user experience issues, which are considered to improve this app and, more generally, to design hiking apps for learning about geology, archaeology, or other fields of interest.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **Empirical studies in HCI**;

KEYWORDS

mobile user experience, hiking mobile app, field testing, geology

ACM Reference Format:
Panayiotis Koutsabasis, Andreas Nikolarakis, Eriana Panopoulou, Stevy Georgiadi, Constantinos Mavrogonatos, and Martin Engi. 2023. Mobile User Experience to Learn About Geology While Hiking: The Syros GeoPaths app. In *2nd International Conference of the ACM Greek SIGCHI Chapter (CHIGREECE 2023), September 27, 28, 2023, Athens, Greece.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3609987.3609999

CHIGREECE 2023, September 27, 28, 2023, Athens, Greece

ACM ISBN 979-8-4007-0888-6/23/09.
https://doi.org/10.1145/3609987.3609999

1 INTRODUCTION

Hiking in nature is a recreational human activity for people of many ages and interests. Hiking often is a relaxed activity that people enjoy, making stops and observations at their own pace. Hiking also can be a learning experience for visitors and tourists in areas of particular beauty or interest for their flora, fauna, geology, culture or other topics. Typically, hikers follow paths that may be previously unknown to them, as they visit an area for the first time. Hikers' safety is crucial. It is related to their experience and physical condition, as well as knowledge about the path and potential hazards. In the mountains, path indications and signs may be scant, so hikers often use their mobile phones to address those challenges. Mobile apps designed for specific areas and paths will guide hikers and help them learn about nature. Hiking apps differ from those for other sports or fitness apps that focus on recording and monitoring users' athletic performance.

Mobile apps about hiking and geology contribute to raise awareness, not only of scientific features, but of the natural environment in general and thus encourage people to preserve and protect it. The experience of hiking and learning about geology should be supported by the app, helping users to plan and prepare measures that allow them to hike safely, at their own pace. It should lead them to points of interest (POI) and direct them to observe geological phenomena in the field.

The design process of mobile apps for hiking and geology must address various issues related to content creation and mobile user interaction, including: pre-recording and representing paths on a map; creating valid content with the help of expert scientists; informing hikers how to prepare well before their hike; helping hikers navigate safely along the path as well as at a POI (micro-navigation); directing hikers to observe geological phenomena and understand them; ensuring service availability even where connectivity may be poor.

This paper presents the design and field evaluation of a mobile app for hiking and geology, called 'Syros GeoPaths', for the case of Apano Meria, a protected area in Syros island, Greece. The goal of this paper is to outline a user-centered process for the development

of this mobile app as well as to discuss experience issues users reported from a field evaluation. The paper is structured as follows: Section 2 presents background and related work about the mobile user experience design with emphasis on hiking apps. Section 3 presents and the current situation and problems of hiking in the designated area. Section 4 presents the design thinking process followed of the Syros GeoPaths mobile app focusing on field visits, content design, interaction and UI (user interface) design, technical development. Section 5 presents the field-testing process for the Syros GeoPaths mobile app in terms of method, participants, and results. In Section 6 we discuss and summarize important user experience issues identified throughout the process.

2 MOBILE USER EXPERIENCE AND APPS RELATED TO HIKING

User experience (UX) refers to a user's perceptions and responses that result from the use and/or anticipated use of a system, product, or service (ISO 9241-10) [9]. User experiences depend on the internal state of the user (e.g. predispositions, expectations, needs, motives, mood, etc.), the characteristics of the product, system or service (e.g. functionality, content, usability, etc.), and the context of interaction. The design of digital products for the user experience is concerned with every element of user interactions including user interface components, layouts, flow, content (texts and audiovisual content), brand, sound, etc. In the case of mobile user experiences, a complex set of features and constraints apply including users being on the move and the app must not require their full attention; mobile device resources must be handled with care (battery can run out, sketchy network access, small screen, etc.); many possibilities for user interactions including sensor-based input/output, voice and text-based interactions and multi-touch gestures.

Mobile devices are widely used for navigation outdoors. Quality issues in route navigation systems for pedestrians are reviewed by Siriarayia et al. [18]. They identify various quality factors beyond finding the shortest route, such as safety (crime-free, accident-free), exploration (POI, venues, novel views), pleasure (nature, scenery) and well-being (exercise, avoiding hazards), and they suggest that route planning algorithms should incorporate such criteria from respective data sources.

Physical activity in nature can be supported by various sports and fitness apps that focus on recording and monitoring user athletic performance depending on the sport (e.g. walking, running, cycling). Such apps have developed a variety of functionalities from personalized training plans, weight loss tracking, to measuring steps and distance covered, estimating calories loss, etc., and some apps also explore social interactions in this context.

Hakkila and Rovaniemi [7] and Anderson and Jones [1] argue that mobile technology has the potential to support activities in nature in ways that can be regarded as calming, relaxing and purifying, provided that the systems developed support users in an unobtrusive manner. For example, the Hobbit app [17] explores the concept of an asocial hiking app, in which users can generate routes that avoid meeting other people.

Many mobile apps address tourists who are interested in learning about local culture and heritage. For instance, Cheverst et al. [1] present a mobile app that explores the English Lake District's cultural heritage, including the poetry inspired by the landscape. A strand of this work includes location-based games for cultural heritage, such as the Mouseion Topos mobile games [12] in which the visitor of a museum takes the role of a local undertaking missions and challenges to explore the museum and nearby village to learn about the local heritage of craftsmanship.

Several mobile apps have been developed for protected areas and natural geoparks. In the case of the Hoge Kempen National Park, Belgium [21], a mobile app aids users to generate, access, and record hiking routes within the protected area, giving basic information about the park, including captivating points, typical flora, and fauna. In the case of the Magma geopark in Norway [13], the mobile app supports treasure hunts and audio guides with the use of GPS and maps. A different approach is followed for the design of the Geopark Odsherred mobile app [6], which incorporates 3D views and augmented reality from the highest point that have been reconstructed in four time periods over the last 25,000 years; this is not a location-based app, and users can access content regardless of being in the park. Finally, a few apps have been developed to aid learning basic concepts of geology in the field (e.g. [17]).

Due to the nature of the hiking activity, mobile apps that support it may benefit from calm design approaches [3], in which interactions between users and technology occur in the user's periphery rather than constantly at the center of attention. The development of mobile hiking apps that promote learning about geology may also benefit from input from domain experts. This paper addresses these issues by presenting detailed case study that applies the design thinking process [15] for mobile hiking apps that promote learning about geology. In addition, in many cases of related work there is not substantial empirical evidence about the design, usability and usefulness of the mobile apps with respect to hiker (user) requirements. This paper contributes to the current knowledge about the user experience of hiking by collecting and presenting several issues identified by a thorough field-testing activity that may be considered for other cases.

3 CURRENT SITUATION IN THE AREA: HIKING AND GEOLOGICAL SIGNIFICANCE

The northern parts of Syros Island are called 'Apano Meria', a protected area with a splendid landscape, one of the best preserved in all the Cyclades. A large part of it is declared a Natura 2000 site, and it is part of a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types that are protected (European Commission, Natura 2000). This world of beauty also harbors a rich treasure of geological features: Syros is eminently significant to geologists as it displays a rich variety of very unusual metamorphic rocks. Intense scientific research (e.g. [1][10]) has documented that the island displays parts of an exhumed subduction zone. This has inspired the project of a Syros GeoPark that is currently being realized. It includes a series of Geopaths that lead visitors to Apano Meria to explore the exceptionally well visible geological features.

Five GeoPaths of various lengths introduce a range of geological topics. The GeoPaths include trails that have been used by few inhabitants and visitors for hundreds of years, albeit so far not systematically maintained or well-marked. The GeoPaths differ

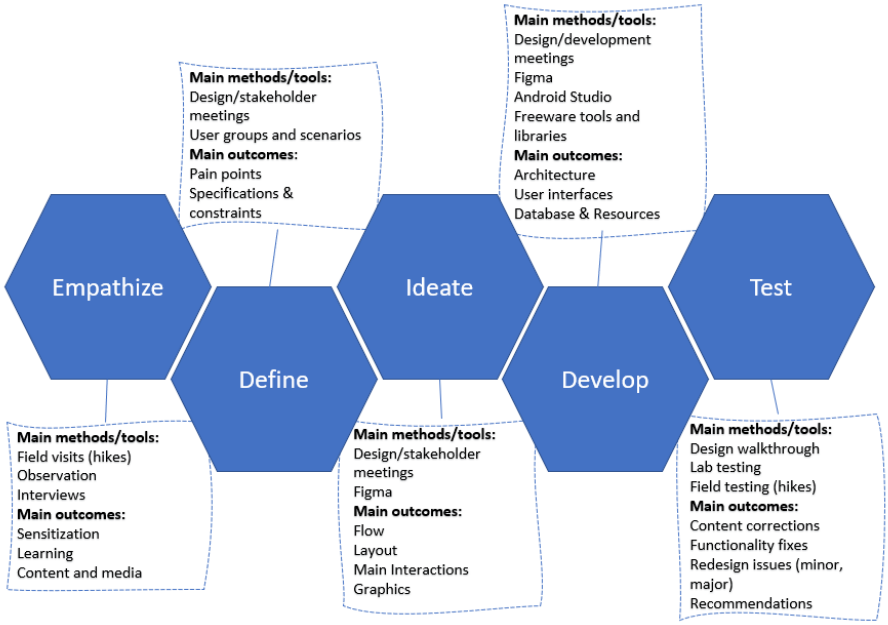

Figure 1: The Syros GeoPaths mobile app was developed with the Design Thinking Process in mind.

in length, and they do require some physical fitness. Hikers must judge which GeoPaths are suitable for their own abilities and time constraints. Most GeoPaths lead to beautiful beaches of the island, and summer visitors often take these paths with the aim to swim or camp. The landscape is virgin and dry. There is neither water nor any emergency response service along the way. Therefore, hikers must be well-prepared before they start to hike in the area, wearing appropriate shoes and clothes, carrying a few supplies (water, etc.), and being aware of a few local hazards (snakes, fire hazard, etc.).

Each GeoPath includes various points of interest (POIs) that present geological processes, rock types, and minerals. Many of these features are linked to tectonic processes that occurred over millions of years when the African Plate was pushed beneath the Eurasian Plate. This giant collision led to the formation of a mountain chain, of which the Cycladic islands today are but the highest remnants, with valleys now submerged in the Aegean Sea. Syros stands out among these islands because it displays an extraordinary range of well-preserved rocks and structural features. These have attracted countless geologists from all over the world to conduct research and field camps for students. By establishing a Syros GeoPark the goal is to raise awareness in the general public and to attract sustainable tourism for hiking to the island.

4 DESIGN AND IMPLEMENTATION OF THE SYROS GEOPATHS MOBILE APP

We have developed the *Syros GeoPaths* mobile application with the design thinking process in mind. Design thinking was proposed in the early 1990s by David Kelley and Tim Brown of IDEO [2]. It is a mindset that promotes the co-operation of designers, users, and other stakeholders in joint learning and creative activities, and a process to achieve these. According to the interaction-design.org, the design thinking process is iterative and comprises of five phases:

(a) Empathize: conduct contextual research to gain knowledge about users and their experience,

(b) Define: identify user needs and project goals based on user experience research,

(c) Ideate: generate creative ideas for addressing user needs and meeting project goals,

(d) Prototype: create representations and artifacts that demonstrate the ideas in practice and test quickly and internally,

(e) Test: show prototype(s) to users and gather feedback for improvements.

The design thinking process is not linked with particular design methods; it is the responsibility of the design team to select or devise these methods with respect to their expertise, the problem at hand and the particular contextual and resource requirements and constraints. In this work, we have adopted various methods, tools, and resources that we considered appropriate at each phase of the process (Figure 1). These combine joint activities (field visits, content authoring, field testing) in the research and evaluation phases of the project, along with design/development/stakeholder meetings. We cooperated with various experts and users, including geology experts, inhabitants and people from local community, hiker groups and other potential users, educators, and students.

4.1 Empathize

We first set out to understand the current user experience of hiking in the area as well as to get acquainted with the geological significance of the place. To achieve these, we adopted an active approach of learning in the field, that mainly involved going on to several

Table 1: Main defining elements of the user experience of hiking with the Syros GeoPaths mobile app.

Pain points	Specifications (content / interaction)	Constraints
If hikers do not wear hiking shoes there is danger of injuries; there is no water available, the sun is too bright and hot, etc. (hikers must be well-prepared)	The app will present GeoPaths with certain length, difficulty, etc. A GeoPath includes several POIs.	Mobile network coverage is sketchy; the app must fully operate without network.
Hikers may lose the path because it is not well visible, and there are no signs.	All POIs must be shown on a map. A POI presents a few geological topics and geological terms.	The app is provided free of charge. Maps must be free of charge (Open Street Maps)
Hikers may observe some geological phenomena but do not understand them.	The app can record user actions and locations and present statistics after the user finishes hiking a GeoPath.	The user must activate the GPS sensor to enable device location tracking.
Hikers may get tired on certain paths due to elevation differences.	The app should contribute to the UX before, during and after a hike.	The user must be able to magnify all images/videos or view in full screen.
A few small parts of the paths may be difficult to hike.	The app must inform user about all required preparations before hiking.	Text to Speech must be available for geological descriptions.
		The UI must be visible in conditions of bright sunlight.
		The app must support English and Greek language (TTS, strings, etc.).

hikes (field visits) guided by expert geologists and including interested members of the local community. Totally, we have gone to about twenty half-day hikes in a period of two years. During these hikes, we conducted several semi-structured **interviews** with other participants, and generated a mass of field notes on facts and ideas based on comments and **observations**. The main outcomes of these activities can be summarized into the development of **empathy** for the natural environment and the people who already hike in the area. We also **learnt** the basics about some geological phenomena that can be observed in the landscape, at large and small scale. Finally, we produced hundreds of **photos and other media**, that would later be reviewed for incorporation into the content of the mobile app**.**

4.2 Define

After we had sufficiently explored the design problem and user needs, we proceeded to **design/stakeholder meetings** to define the basic elements of the *Syros GeoPaths* mobile app. During these meetings we reviewed the experience of field visits and explored several hiking **scenarios** that would use the mobile app. The main defining elements of the mobile experience were classified into user pain points, content specifications and mobile user experience constraints that had to be respected. These are summarized in Table 1.

4.3 Ideate

The ideation process typically occurred in design meetings. Ideation was about several design elements like the interaction flow of the app, layout of main screens, particular interaction patterns or widgets (like lists, maps, image galleries, etc.), and elements of visual identity (logo, colors/styles, fonts, icons, and graphics). A prototype was developed in Figma. The prototype was reviewed by geology experts and stakeholders and the design team several times, as some ideas and concepts were tested and rejected in favor of others. The prevailing visual design is depicted in Figure 2. The design of the Syros GeoPaths mobile app has followed the key principles of calm design that promote peripheral attention, context, and ambient awareness [3]. Design choices that reflect the main specifications and constraints to be met include the following:

- A high-contrast UI theme was chosen to promote high visibility of the app in conditions of bright sunlight.
- The three main aspects of user experience: plan, hike, achievements are clearly described during onboarding and in the start screen.
- A check list of important provisions that every hiker must take is provided.
- All GeoPaths are presented in a list with relevant information about length, difficulty, etc.
- Each GeoPath is viewed in detail with the use of an elevation profile diagram, a map, and a list of POIs.
- The GPS sensor must be enabled so that the app calculates the distance of the device location to all POIs. The user can view and refresh their own position with respect to all POIs.
- Each POI contains a photo gallery, and 1-3 geological topics.
- Each geological topic contains a photo gallery and 1-5 geological terms.
- Each geological term contains a photo and description.
- Each POI, topic, geological term can be spoken aloud with Text-To-Speech (TTS) technology.
- After the user visits all POIs of a geopath, they earn an achievement certificate that shows statistics about the hike (e.g. distance covered), and app usage (e.g. views of geological terms). Users are also encouraged to share it on their social media.

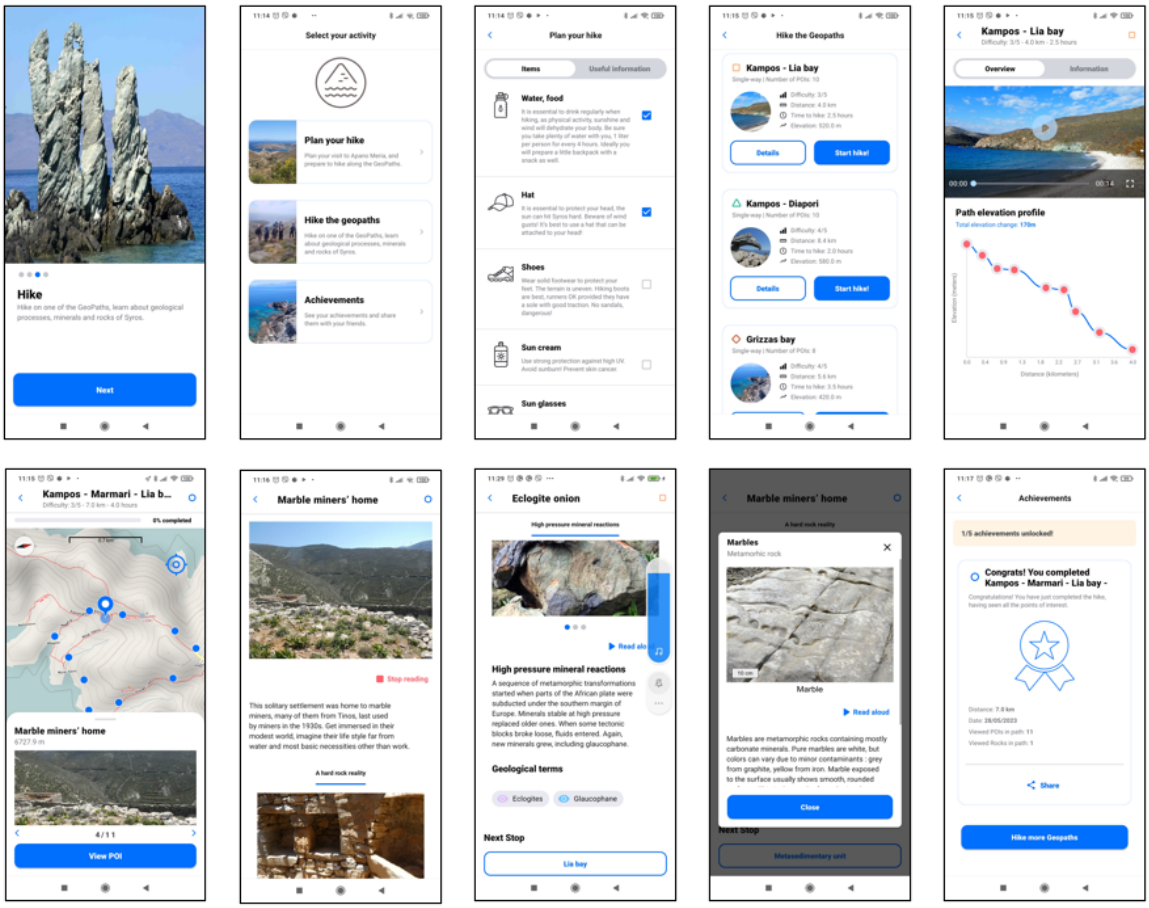

Figure 2: Screen shots of the Syros GeoPaths mobile app. Functionality explained from upper left: Onboarding | Start screen | Plan your hike (select items) | Overview of GeoPaths | (Selected) GeoPath overview | POI overview (on map and horizontal list) | (Selected) POI detailed view | (Geological) topic detailed view | Achievements.

4.4 Develop

The technological and software development of the Syros GeoPaths mobile app was made in Android Studio with Java programming language. The app makes use of OSMDroid, an open-source library that provides OpenStreetMaps to Android. The maps are pre-loaded during installation, they work without requiring access to a network. All texts and graphics have been optimized for Android apps and these are also embedded in the app. A local database has been developed as part of the app, it can locate all GeoPaths, POIs, topics, geological terms and respective resources (strings, photos, videos, graphics, etc.). The content of the app is provided in the English and Greek language.

Regarding content production and development, from the wealth of potential topics identified throughout field visits, a selection was made to provide a didactic introduction to various geological phenomena, by geology experts. The aim was to concentrate on a distinct set of relatively few themes along each of the five GeoPaths, to render the complex geological history of Syros amenable.

5 FIELD TESTING OF THE SYROS GEOPATHS MOBILE APP

5.1 Aims and method

The aims of the evaluation were (a) to assess key design choices and remaining concerns by participant observation, (b) to identify possible functionality issues or bugs that might appear in the field, and (c) to record all comments, questions, and corrections made by participants. We employed the method of field testing in a similar manner to [9]. The field tests occurred in two days. On each day, two GeoPaths were selected for hiking (i.e. four paths were tested in total). Participants were accompanied and observed by researchers. All participants were interviewed throughout the process, and as issues came up. The researchers kept notes by various means, mainly with their mobile devices: digital notetaking, screenshots, short video notes.

5.2 Participants

We recruited participants with variable profiles, who hiked the GeoPaths using the mobile app. All participants had downloaded

Table 2: Participants per hike / field testing session

	Hikes / field testing sessions					
	Geopath 1	Geopath 2	Geopath 3	Geopath 4	Total	Total (unique)
Participants	10	4	9	4	27	21
Researchers	2	1	1	1	5	3

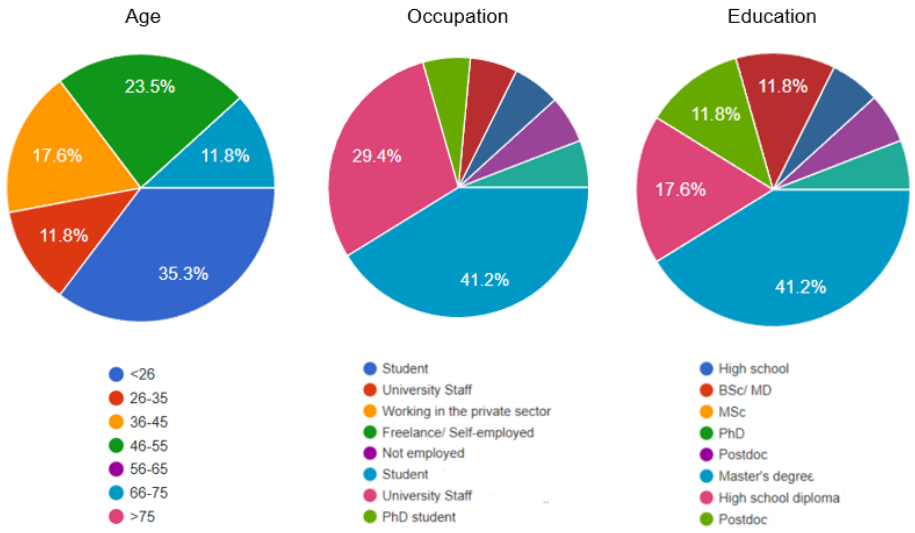

Figure 3: Participants' age, occupation, education level.

the app the day before on their devices and they had the opportunity to review it beforehand. Four participants did not own an Android device and they were provided with one, the day before the hike. The total number of participants was 21, nine women; six participated on both hikes/days. Participants selected their preferred GeoPath based on their physical condition. Three researchers accompanied participants throughout the field testing and hiking activity. The completion of questionnaires was optional.

Most participants were recruited from academia. The profile of participants ranged substantially. In terms of age, they ranged from 21 to 69 years. Their expertise ranged from undergraduate students to university professors. Most participants used the app in their native language; a few switched to English based on their preference. Greek native speakers were 18/21, while all participants were fluent English speakers. About half of the participants were frequent hikers (53%). Most participants reported a relatively good physical condition (equal or above 7/10). More than half of the participants (58%) reported that they had never used a mobile app for hiking. Nearly one-third of participants (29.6%) were geology professors or students, who could provide specific comments about the content of the app.

5.3 Results

5.3.1 Findings from participant observation during the hikes, and survey responses. Eighteen participants filled out the survey questionnaire. All findings were encoded by the research team into the following categories: functionality (the technical quality of the app), usability; content quality (texts, photos, data), navigation support, user story (about observed user behavior and preferred or nice-to-have features). A total of 116 findings were recorded by users, 52 of them unique. They were classified into very important (2 issues, 2%), important (12 issues, 10%, minor (22 issues, 19%), cosmetic (16 issues, 14%), and not a separate issue (i.e. mostly these were multiple mentions, 64 issues, 55%).

Figure 4 (left) shows the classification of findings into categories. Most findings (22 issues, 42%) were about geological content: questions or corrections to texts, terminology, and photographs. 16 issues (31%) were about usability; these were mainly about the ambiguous design of a few icons and the interactivity of some elements, especially on the map. Another ten (19%) issues were related to functionality, most strikingly a few unexpected GPS glitches that showed the user quite far from the actual location (several km!). A few issues were reported about navigation, most importantly that the paths must be cleared and signed so that the app would not have to support detailed navigation, except when the hiker may have gone far from the path.

5.3.2 UEQ responses. To complement data from participant observation and survey responses, we employed the User Experience Questionnaire (UEQ) [17] which allows immediate quantitative measurement of user experience and benchmarking. Sixteen participants filled out the UEQ questionnaire. UEQ uses 26 Likert-scale (7-point) questions to measure six scales; attractiveness (overall

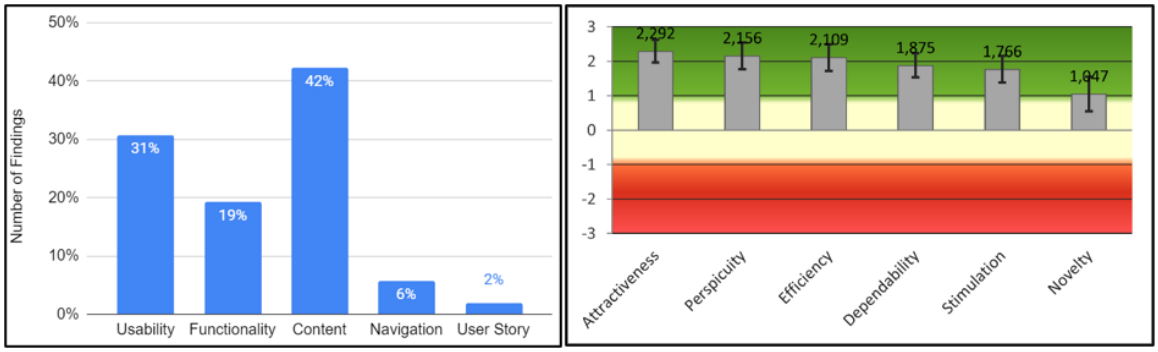

Figure 4: Left: Taxonomy of findings from participant observation and survey responses. Right: UEQ scores.

impression of the system), clarity (how easy it is to get familiar with the product), efficiency (can users solve their tasks with the product without unnecessary effort?), dependability (does the user feel in control of the interaction?), stimulation (how exciting and motivating is to use the system?), and novelty (how innovating and creative is the system?).

UEQ responses were interpreted with the UEQ data analysis tool [17] (Figure 4, right). The mean scores of all six scales ranged from 1.047 to 2.292. According to Schrepp [17] "it is extremely unlikely to observe values above +2 or below −2... the standard interpretation of the scale means is that values between −0.8 and 0.8 represent a neutral evaluation of the corresponding scale, values > 0.8 represent a positive evaluation and values < −0.8 represent a negative evaluation". In these terms, our results demonstrate a positive user experience for all participants.

6 DISCUSSION AND CONCLUSIONS

We reflect on several issues of the user experience of hiking with the Syros GeoPaths mobile app, which may be considered for the redesign of the app and, more generally, for hiking apps for learning (about geology or similar fields).

GeoPath Clearing and Signage. The GeoPaths are not yet cleared and signage is not yet present. This limits the hiking experience, especially regarding user (micro-) navigation and hikers feeling safe. Once signage is provided, it will be exploited in the Syros GeoPaths app design to include QR-codes or image recognition technology (in ways similar to [5]).

Planning and Warning Enhancements. We identified a few missing issues about planning the hike to the Syros GeoPaths. These are related to a few local hazards that may come up (especially to pay attention to snakes that might be seen near the paths), so hikers must be made aware. Since hikers may be tourists or visitors who visit the place for the first time, they may be quite unfamiliar with the specific natural environment and its potential hazards.

Dynamic Map Design Features. The digital map is the most important feature of the app. It must be interactive and provide various indications about the user approaching a POI or about POIs already viewed. A few improvements were identified during field testing, which could not have been discovered in the lab.

Passive Notification Support. Before field testing, we were uncertain whether passive notifications would be valuable for hikers. One point of uncertainty was whether notification should be about approaching a POI or/and about hiking away from the path. Additional technical challenges concerned the design and implementation of a notification system based solely on GPS data for an open landscape (with no signposts, road or street information). Field testing has shown that notifications are not required since hikers generally could navigate along the path we had drawn onto the digital map.

Micro-navigation Support. We refer to micro-navigation when a hiker is very close to the POI of interest but still needs to identify the exact spot. This occurred a few times on specific POIs that included several geological topics and terms with different issues to be observed and related photos. Photo captioning should be added, while detailed signage on-site can also help.

Micro-interaction improvements. A few micro-interaction improvements were identified in the process of field testing. For example, showing POIs visited in a different color on the digital map will help the user remember places visited. Or showing the list of POIs into the map from the last POI the user had has visited is required when the user views POI details and then moves back on the digital map. Such micro-interaction issues may significantly improve the user experience, and they are very hard to discover without an empirical field-testing process.

Narrative and content development. Several issues were discovered about the narrative and content developed. The selection of TTS voice was not acceptable for some users, and they needed help to change this (they could do that from device settings, but the app should guide them how). More importantly, we identified various issues about text phrasing and consistency of terminology. These are important in some circumstances and very easy to fix.

This paper presented the design process, design rationale, and the findings of an empirical field-testing process of the Syros GeoPaths mobile app that supports visitors and tourists to hike and learn about the geology of the protected area of Apano Meria in Syros Island Greece. The design of the app follows key principles of calm design that promote peripheral attention, context, and ambient awareness. The software implementation approach builds on open technologies (Android, OpenStreetMaps) and addresses the constraint of sketchy network availability by embedding all content

into a local database. Empirical evaluation was carried out with field-testing sessions that allowed us to identify several user experience issues in an authentic context of use. We propose that the design process followed, and empirical findings presented in this paper may be a useful case for other practitioners who work on mobile apps for hiking and learning about geology.

Future work includes fine tuning of the design and development of the final version of the app. At the time of writing the app has not released to the Google Play Store, however this is a planned action after fine-tuning. Another action for future work is the evaluation of the learning effects to various groups hikers and visitors, including teachers and pupils, geology students and academics, tourists, residents, and others. Other actions that may be identified after the release of the app might include updates of geological content as well as addition of content for more geopaths.

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