

Mobilogue – A Tool for Creating and Conducting Mobile Supported Field Trips

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ABSTRACT

Mobilogue is a tool to support educators and students in authoring and deploying learning support with location awareness and guidance to mobile devices. The application area of the framework covers informal learning settings like field trips, museum visits as well as formal classroom settings. The focus of the framework is on the simplicity and flexibility of the domain independent content authoring and content deployment. We present an authoring tool that uses a graph-based paradigm to model and author a path across different locations. Locations relate to physical places or artefacts through QR codes and provide supportive information. The guidance takes place by identifying the user's location by scanning the QR codes and visualizing the appropriate information on the smartphone. Finally we describe possible scenarios for such informal learning settings and report on an evaluation of the framework in a museum setting.

Author Keywords

mobile learning; field trips; museum; authoring; quiz; simulation

INTRODUCTION

Field trips have been and still are a very popular alternative and addition at the same time to in-classroom learning (DeWitt & Storksdieck, 2008). Such out-of-school settings usually focus on informal learning environments like museums, zoos or other outdoor settings like cultural or historic heritage places. These places often do not serve for visitors only, but also provide classes, tours and other activities targeting schools. The added value for the students is the real experience of an exhibit, a historic place or technical equipment that is not available in the classroom and therefore cannot be learned by the students (Kiesel, 2005).

Mobile devices are very well suited for informal learning scenarios (Sharples, Taylor, & Vavoula, 2005). Due to the small size and the high portability, mobile devices can be used outside, e.g., in museums (Vavoula, Sharples, Rudman, Meek, & Lonsdale, 2009; Yiannoutsou, Papadimitriou, Komis, & Avouris, 2009) or other informal settings. The continuously evolving technology brings new generations of mobile devices year by year, making them more powerful and more feature rich with every iteration. GPS sensors and high-resolution cameras increase the potential to utilize modern smartphones in outdoor activities, like location based games (Giemza, Verheyen, & Hoppe, 2012) or treasure hunt games (Botturi, Inversini, & Maria, 2009).

Many museums have already made use of the potential of the smartphone as a digital assistant or tour guide for the visitors and provide dedicated smartphone applications. Countless apps exist in the smartphone apps markets, like the Apple App Store or the Google Play. While these mobile guides support the visitor, they are usually very general and do not necessarily provide adapted material for educational purpose. On the other hand many other locations for outdoor activities, like historic heritage places, do not provide any kind of digital visitor support.

This issue is an opportunity to embed the creation of a location specific guide as a basis for informal learning activities. This can foster the engagement of the students with the topic or domain of the place in question and therefore increase the learning effect and the identification of the learner with the task itself. A crucial requirement for realizing such activities is a system that is powerful and flexible enough for creating mobile guides on the one hand, and easy understandable and applicable for school teachers and students.

This paper presents a framework for authoring and running mobile scenarios with quizzes and location guidance for various application domains targeting simplicity and universal applicability. The environment called Mobilogue ("MOBile LOcation GUIDance") comes with an authoring interface that allows for creating guided trips based on locations, which contain information about the location, optionally a quiz and multimedia data, and finally a recommendation for a next location – to define a route. The framework also offers a mobile Android application for executing the scenarios in the field.

In the following section, we will discuss related work and present indications that simple and flexible authoring support for simple field trip creation for schools is currently largely missing.

RELATED WORK

Educational content authoring does not only require knowledge about the domain but also some knowledge about pedagogy and last but not least draws on authoring tools. Content authoring for location-based activities adds the location dimension to it, thus adding another layer of complexity to the task.

The topic of mobile content authoring tools is no longer only a research topic but has already reached the commercial area. Currently the most popular device in this context is the Apple iPad that finds a high acceptance in schools nowadays (Henderson & Yeow, 2012). The advantage to the classical textbook is the availability of interactive content and applications for education. As an alternative to prefabricated content, Apple provides iBook Author as an authoring tool for creating own interactive (proprietary) textbooks. This empowers everyone to create (educational) content, e.g., content created by a teacher for his/her own students or even the students for themselves.

GoMo Learning (GoMo Learning, 2013) is a commercial content authoring tool specialized on multi-device content delivery by utilizing Web-technologies (HTML, JavaScript and CSS). It supports a collaborative and web-based creation of content that can be delivered as a HTML package or a native application for the different devices. In contrast to Mobilogue, GoMo created scenarios do not support location based content delivery based on QR code detection. Finally, the high yearly license fees might be an obstacle for the application within the school context.

Treasure-HIT (Kohen-Vacs, Ronen, & Cohen, 2012) is a research project that supports a treasure hunt game in the field on mobile devices. The system offers an authoring environment for teachers to create station-based activities for GPS-identified locations with content, tasks and feedback for the learners. These games are shared through a repository and can be run on mobile phones in the field. Treasure-HIT also uses Web-technologies for content visualization on the devices, thus making it platform independent. Although this project is very related to Mobilogue, it does not support running scenarios inside buildings, as GPS is the main trigger for location detection.

A crucial issue with guidance or navigation applications is the awareness of the user's location. Many projects (Ballagas, Walz, & Borchers, 2006; Giemza et al., 2012; Kohen-Vacs et al., 2012; Spikol & Milrad, 2008) for outside activities rely on GPS to detect the exact location. Indoor activities need to handle the position detection using alternative techniques. Bahl and Padmanabhan (2000) present a framework for detecting and tracking the user's position based on radio frequency (Wi-Fi) triangulation. Other examples (Föckler, Zeidler, Brombach, Bruns, & Bimber, 2005; Ruf, Kokiopoulou, & Detyniecki, 2008) introduce frameworks that use on-device object recognition to present the appropriate information to the user. Mody et. al (2009) propose RFID tags as indicators of the user's position by explicitly scanning a RFID tag attached to an exhibit. The downside of these technologies is that they either rely on an existing infrastructure at the application location (Wi-Fi signal), require complex pre-configuration of the settings (creating an object database for the recognition) or last but not least demand a particular technology on the smartphones of the users (RFID scanners are still rarely available on modern smartphones).

In contrast, Mobilogue uses a simple but widely applicable solution to detect the user's position. The authoring environment can generate QR codes (see Figure 5b) from authored locations without any complex configuration or preparation. These codes can be printed out and put to the physical location at very little cost. These codes can be scanned with almost all Android-based smartphones using the usually available camera. In the next chapter we will present the Mobilogue framework in more detail including the authoring environment, the repository and the mobile application.

MOBIOLOGUE

Mobilogue maps the concept of field trips onto guided tours across multiple (physical) locations supported by a mobile device. The learning takes place at the single locations by providing content related to the place or an object at that place and additional stimuli to foster interaction and curiosity by challenging the learner with a quiz. Locations can be seen as stations of a tour. Each location has a name and a description to provide adequate contextual information for the user. Additionally, a picture, GPS coordinates and a quiz can be added to a location. The GPS location information is used to support the user in finding the way between two locations in outdoor settings, but is optional. The picture can help to recognize a location or can act as an element of a quiz. The quiz itself brings the gaming aspect into the learning activity. It requires the learner to engage with the location and the context to succeed in the quiz. A quiz consists of a question and four answers, of which only one is correct. This concept can be easily mapped to real-world scenarios, e.g., guidance across areas or rooms in a museum or compounds in a zoo. However, it can also be mapped to non-spatial entities, e.g., like computer parts for supporting learners in assembling a PC by scanning tags and providing instructions (El-Bishouty, Ogata, & Yano, 2007). In Mobilogue a location is always associated with a QR code, i.e., each location is identified physically by a QR code that has to be scanned to retrieve the content. The code itself only encodes a unique id that is a reference to the location information.

In summary, Mobilogue consist of three elements: the authoring environment to create mobile guidance scenarios, the repository for storage and exchange and the mobile application for running the authored scenarios. In the following we will elaborate all three parts of the framework.

Authoring Environment

The main idea of Mobilogue is to empower teachers as well as students to create field trip scenarios without the need to learn a complex authoring tool or to care about the technological background. The basic concept of the authoring environment is related to the activity of consuming (multimedia) content in different locations in a certain (guided) order. The authoring tool allows to create such locations and to organize them in a sequence as the guided field trip for the learner through different locations.

Mobilogue has been developed as a Plug-in for the graph-based modelling environment FreeStyler (Gassner, 2003; Pinkwart, Hoppe, & Gassner, 2001). While FreeStyler provides the main graphical user interface and handles the graph model rendering and interaction, plug-ins typically define a set of graph nodes (objects) and links, building the plug-in's domain language. Each language comes with a "palette" (see Figure 2) of options to select from, which is displayed at the right hand side of the FreeStyler window (see Figure 1a).

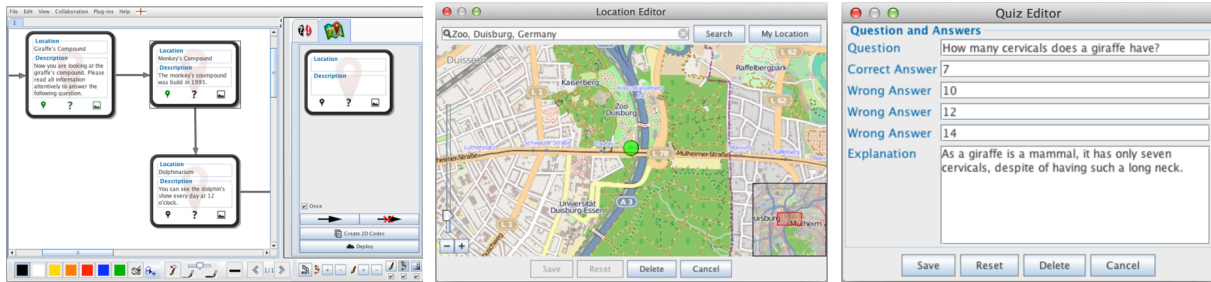


Figure 1: (a) FreeStyler with Mobilogue Plug-in, (b) GPS Position Editor, (c) Quiz Editor

The main building block of Mobilogue is the location node. A location node represents a physical location or place and has a title and a description (see Figure 1a). The physical (GPS) location can be added through a map tool (see Figure 1b) that is available on the lower left place icon inside the node. The GPS information is optional and will only be used to support the user in finding the next QR code in outdoor settings.

The question mark in the lower centre of the location node opens the quiz editor for the location (see Figure 1c). This allows extending the scenario using quizzes to stimulate further activities at the location, e.g., search and investigation to solve the quiz. A quiz consists of one question and four answers, of which only one can be correct. Additionally, an explanation to the question and the correct answer can be given, which will be presented to the learner after answering. This might help the learner to understand the answer and to learn from the quiz, instead of simply receiving the result (correct / wrong answer) of the quiz. Finally, the picture icon on the lower right opens the picture attachment tool, with which the author can add a picture to enrich the content presentation for this location.

Figure 1a shows an excerpt of a field trip scenario for the Zoo in Duisburg, Germany. The green colouring of the icons indicates that this location node has a GPS location, a quiz and a picture attached. The ingoing and outgoing arrows represent the order of the guided tour. Figure 1a shows the "Monkey's Compound" as the only successor of the "Giraffe's Compound" location. This example shows a linear walkthrough with no alternatives after visiting the giraffes. However, the tool supports multiple incoming and outgoing edges, allowing the design of multiple ways and guides throughout one scenario. The whole modelling process – based on FreeStyler – uses the direct manipulation paradigm. Nodes can be dragged from the palette on the right and dropped into the working area in the centre. Links are added by selecting the linking tool in the palette (arrows in Figure 2) and connecting the nodes by a click and drag operation.

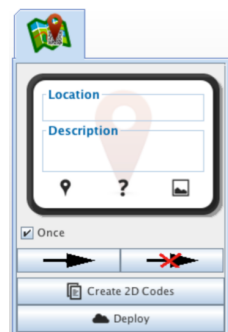


Figure 2: Mobilogue Palette

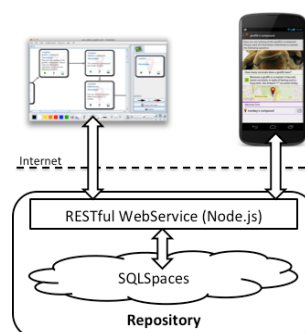


Figure 3: Mobilogue Architecture

The final steps of the authoring process are the publication of the scenario into the repository and the printing of the QR codes. The two options can be found in the bottom part of the Mobilogue Palette (see Figure 2). Deploying a scenario to the repository makes it directly available to users. The second step of the process is to create QR codes for printing them

out and distributing them at the foreseen location. Mobilogue provides a functionality to automatically generate these codes with an optional description of the location and finally creates a PDF file that can be stored, shared or directly printed.

Repository

The repository is the mediator between the authoring environment and the mobile application. Figure 3 shows an overview of the architecture. It provides storage and lookup facilities for the shared data. The technical implementation uses the SQLSpaces (Weinbrenner, 2012) as a blackboard architecture and Node.js for the RESTful Webservice (Fielding, 2000) to store and access the data in JSON format.

A unique identifier (uid) of the location is encoded in the QR code. This uid is used to retrieve the location information and all the attached content (quiz, image) to it. Due to the JSON protocol and the RESTful Webservice interface, this architecture is very open and therefore accessible to other devices and new implementations for Mobilogue.

Mobile Application

Last but not least this section will present the mobile application of the Mobilogue framework. The Mobilogue app is the runtime for the location guidance scenarios. It has been implemented as a native Android application and designed with simplicity in mind to avoid any kind of configuration or setup issues for the user. The only required action before starting is the login or the creation of an account (see Figure 4a). The account is used to distinguish activities by multiple users on one phone. This feature allows Mobilogue to scale within classroom settings (Giemza et al., 2012), where students without an own Android device can share one device, e.g., provided by the school. Afterwards the activities are available to the individual students from a list to reflect on the visited locations, the information and the quiz result if available.

Once the user logs in, he or she will find the main activity with the visited locations (empty in the beginning) and the QR code button to activate the scanner (see Figure 4b). The scanner is used to scan the found codes that identify a location. Once the code is scanned, Mobilogue will automatically retrieve the location information from the repository. If the code is not valid, i.e., is not a Mobilogue code and therefore does not exist in the repository, the application will prompt an error and ignore the scanned code.

A valid location code will open a new screen with the authored content for the particular location. Figure 4c shows the screen with text from the Zoo scenario, a picture of a giraffe and a quiz that has been presented as a location node in the authoring environment in Figure 1a. The text from the location node (Figure 1a) is now visible above the picture of the giraffe in the mobile application (Figure 4c). This location has a quiz attached that has not been solved by the user yet. The text above the picture suggest to the learner to read the information located at the compound of the giraffes to find the answer to the question. The learner will have to answer the quiz in order to get the guidance, i.e., the information where to go next. Once he or she answered the quiz, a result dialog will pop up (Figure 4d) and provide the correct answer with an explanation and the result of the users choice. In this case the answer “10” provided by the user is wrong.

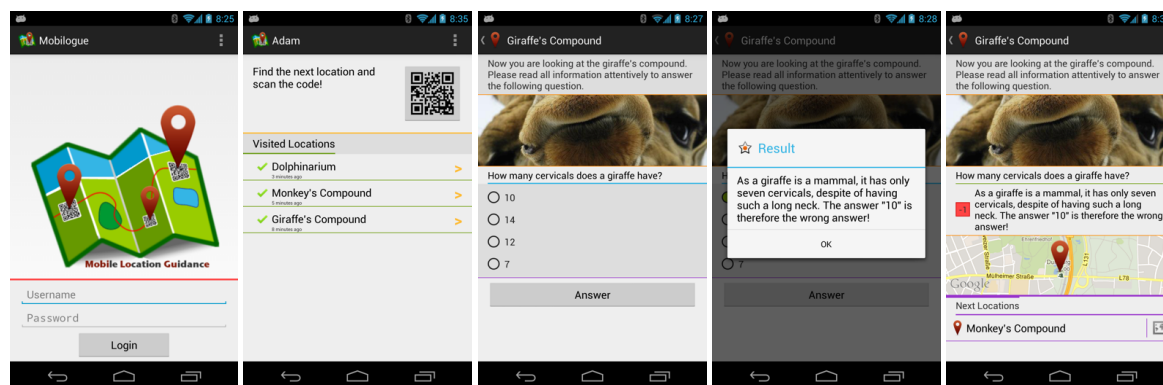


Figure 4: (a) login screen, (b) main screen, (c) location screen with quiz, (d) quiz result dialog, (e) location result screen

The result of this quiz will be store on the mobile phone and the location view will be updated to provide additional information (see Figure 4e). First of all the quiz is removed and replaced by the initial quiz question and the result of the quiz. The result includes a score (red square with -1 for a wrong answer, green square with +1 otherwise), the explanation of the correct answer and answer chosen by the learner.

Additionally, a map of the current location is rendered to give the users the ability to locate themselves on the map. Below the map all next locations are listed, that the learner can visit next after this place. Although the example scenario only provides one next location (cf. section Authoring Environment), other scenarios may provide multiple next locations that the user can chose from. This is only a recommendation for a next location. The tool will accept any other scanned location as the next one. The “Monkeys’ Compound” is the next recommended location from the list in Figure 4e. The list item has a map icon on the right hand side. This indicates that this location also has GPS information attached that

can be used to support the user in finding the location. If the learner selects (touches) this location, a big (Google) map with a compass on top will be opened and visualize the current location of the user (blue circle) and the location of the next location, i.e., the monkeys' compound. Unfortunately, Google Maps does not provide a detailed map for the Duisburger Zoo. A more problematic case are scenarios inside buildings, where neither GPS nor (detailed) maps are available. These cases will be discussed later in the conclusion and outlook.

After the learner has found the next location, he or she can go back to the main screen and start the scanner for the new QR code. The main screen will fill up with the visited locations and give the learner access to his or her past activities (see Figure 4b). The list items show the title and the (elapsed) time of the visit of the location. For follow-up activities and reflection the learner can select the visited locations and "revisit" them on the device. In case of the giraffe's compound the resulting screen will be the same as shown in Figure 4e.

Finally, the user can delete the activity log and re-run the whole scenario. The Zoo scenario has been used for a pilot study of the mobile application with six users. In the next chapter we will describe the evaluation of the Mobilogue authoring environment and the mobile application in a museum context.

EVALUATION

We have conducted two interconnected trials using the Mobilogue framework. The first trial was a feasibility study of the authoring environment to explore the simplicity and the capability for creating real scenarios. The second trial was a usability evaluation of the mobile application using the scenario created in the first trial. Both evaluations were carried out in collaboration with the TOP SECRET museum in Oberhausen, Germany. The museum covers the broad topic of spying. It shows the history of Germany during and after the Cold War, provides information about secret services, famous spies and agents, and presents many collected exhibits from the past and the present of espionage. Looking at the school context, these topics will most likely suit history courses. Topics like Internet crime and ciphering are also covered, which might be more useful for technical affined visitors or a science-oriented class. Furthermore, the museum presents less serious topics like agent movies posters or an Aston Martin from a James Bond movie. The museum offers special guided tours for kids as well as for schools. The goal of the evaluation was the creation and the execution of a guided tour on mobile devices with quiz elements to foster students' engagement with the exhibition.



Figure 5: Students in the school (a) authoring locations, (b) rating the printed locations, (c) final scenario

Authoring Environment

The first trial was the evaluation of the authoring environment with twenty 10th grade students ($N = 20$, 17 male, 3 female) in a secondary school (Elsa Brändström Gymnasium Oberhausen, Germany). The teacher gave an introductory lesson to the field trip before visiting the museum. At the museum the students received a guided tour with additional time for an individual walkthrough. Afterwards in the classroom, the teacher presented the task for the students to create a guided tour using the Mobilogue framework. For this purpose the students had the possibility for additional individual visits of the museum to make notes and select meaningful locations and exhibits. Furthermore the students were asked to come up with quiz questions. The subtle motivation of this setting was to stimulate the students' interest in the topic and provoke a kind of "learning by teaching" effect. After a week the students compiled the collected material into several Mobilogue locations using the authoring tool (see Figure 5a). Finally, all created locations and quizzes have been printed and graded by all students (see Figure 5b). The best-graded locations have been collected by the teacher and compiled to a Mobilogue scenario for the TOP SECRET museum.

We have observed the students during the creation process and helped with explanations in few occasions. The authoring environment has been accepted quite well, as the students have already been working with FreeStyler and other plug-ins before. The difficulties for the students were rather creating rich content for the locations. Many of the locations either did not have any description at all, a very general description like "Welcome to the next location..." or an instruction like text what to do here. This has been fixed together with the teacher in the final compilation phase. Figure 5c shows the final result.

Some students were very enthusiastic about the overall concept and were very creative with content and quizzes. We were able to raise this enthusiasm by handing out the mobile devices so that the students could actually see their work on the mobiles. This immediately pushed them to rework some of the content and improve their quizzes as well.

Afterwards we interviewed some of the students about their experience using the Mobilogue authoring tool. Overall the response was very positive. The students were really amazed by the fact that they could actually “produce a mobile app”. One student also mentioned: “It was very easy, we did not even have to program anything or care about the technical details”. Some students even suggested extensions to the authoring tool, e.g., (only) showing pictures after a quiz has been answered, or forced roots in the guidance. Finally, the teacher and the students have considered the trial very positive.

Mobile Application

The second trial was targeted to evaluate the usability of the mobile application running the scenario created by the students described in the previous section. We have evaluated the usability of the mobile application following the dialogue principles for ergonomics of human-computer interaction (ISO 9241/10).

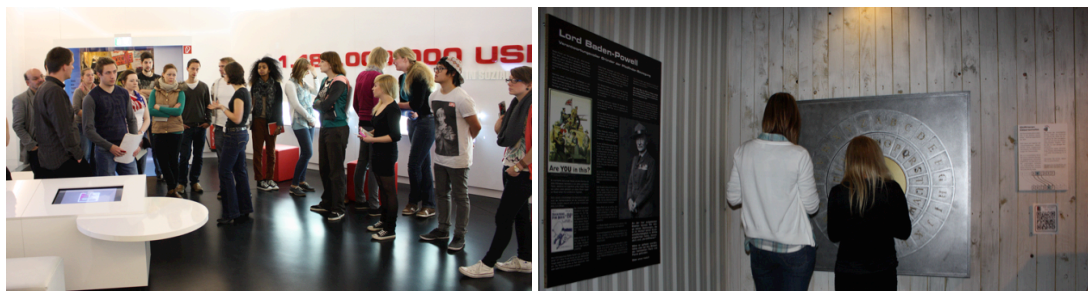


Figure 6: (a) informative tour for the students at the museum, (b) students using a disc with the Caesar cipher

We invited eighteen University students from the Bachelor courses of applied computer science and the Bachelor courses for applied cognitive and media science ($N = 18$, 8 male, 10 female) with an average age of 23.16 ($SD = 1.8$) for the purpose of the usability study. The students received a short introduction to the evaluation and the context of the museum. Afterwards the students received a tour (see Figure 6a) with less guidance and limited information about the single areas of the museum. The intention here was not to spoil the second run with the guided tour using Mobilogue. During the guided tour using the Mobilogue app, the students had to follow the predefined route and answer the quizzes created by the class. The questions varied from simple information gathering from the museum’s exhibit plates to rich interaction questions like decoding an encoded word using the Caesar cipher disc available in the museum (see Figure 6b).

After the guided tour the students were asked to answer a questionnaire. The questionnaire was separated in three parts. The first part (A) covered almost all dialogue principles of the ISO 9241/10 standard:

Suitability for the task (A1), Self descriptiveness (A2), Controllability (A3), Conformity with user expectations (A4), Error tolerance (A5), Suitability for learning (A6)

We did not take the “Suitability for individualization” into account, as Mobilogue does not provide any kind of individualization, so this would confuse the students. The second part (B) covered specific questions directed to the application of Mobilogue in the museum context. We have formulated 5 questions for the items:

Attention (B1), Guidance (B2), Motivation (B3), Appearance (B4), Amusement (B5)

The third part (C) of the questionnaire was a qualitative judgment of the application. It consisted of the question if the user would recommend this application in the museum context and a free text form for a summary, comments or suggestions.

Part A and B were evaluated using multiple questions. Each question was rated on a scale from -2 (fully disagree) to 2 (fully agree). This rating has been later mapped onto a 5-point Likert scale from 1 to 5 with higher values being better. Figure 7a shows the mean and standard deviation values.

Overall, the results concerning usability (Part A) are very positive. The subjects judged the principles A1 ($M = 4.29$, $SD = .84$), A2 ($M = 4.29$, $SD = .87$), A4 ($M = 4.59$, $SD = .63$) and M6 ($M = 4.78$, $SD = .39$) very positive. This shows that the application is suitable for the task, self-descriptive, conforms to the users’ expectations and is also easy to learn. The principle A5 ($M = 4.00$, $SD = .99$) concerning the error tolerance shows a high deviation with a still positive mean value. Reasons for the high deviation can be interpreted from the comments in part C. One user reported a crash of the application and problems in scanning the QR codes, caused by the flash not being automatically activated in darker locations. We need to identify the reason especially for the latter as this is a crucial requirement for the scanner to work. The lightning conditions have to be taken into account when placing the QR codes. The principle A3 that has received the lowest rating concerns the controllability of the application, i.e., the question if users can control the process or if the application enforce them to follow fixed steps. From the description of the application it is evident, that the application foresees a certain order of actions (find code, scan code, read location material, solve quiz, find next location and code, etc.). This leaves very little room for the user to deviate from this workflow. On the other hand, the user is free to scan

any code and is not enforced to follow the recommended route of the scenario at all. On comment from a user who gave A3 the lowest value was that app ignores many exhibits and ignores many interactive elements of the museum. This is obviously specific to the created scenario and is not a limitation of the application.

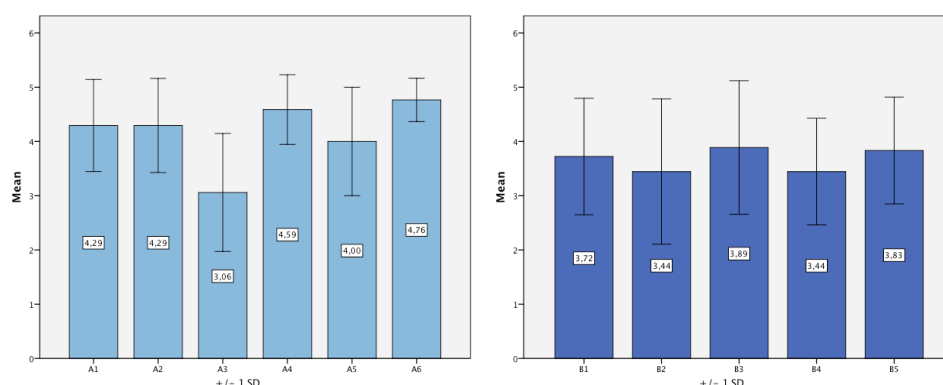


Figure 7: (a) Usability evaluation results (Part A), (b) Evaluation results (Part B)

The evaluation results for part B (Figure 7b) also show a quite positive result, although the overall deviation is higher compared to the result of part A. In total we can say that the application raised the attention towards the exhibition and did not disturb too much (B1). One user pointed out that the application does not cover the whole museum. This is again scenario specific and does not relate to the application as such. The guidance received a lower rating (B2). This result can be explained by the lack of an indoor map functionality. The motivational aspect of the app has been rated highest within part B. This indicates that subjects have been motivated by the app to explore the museum and to solve the quizzes. One user argued that the quizzes were too easy and that one only had to parse the texts in the museum to solve the quizzes. Obviously this is an issue that needs to be taken into account with a next design of a scenario. The appearance and design of the app has also been rated quite good (B4). Last but not least the users reported that they have enjoyed the mobile-guided tour and that the app improved the visit.

The recommendation rate of the application of Mobilogue in the museum context was around 88% (16 out of 18 would recommend the app). This and the mostly positive comments in part C reflect the overall positive outcome of the evaluation. The result also shows that the scenario plays a very important role in the reception of the whole application and that the judgment might become indistinct.

CONCLUSION

We have presented an approach and concrete tools that provide general functionality to support the creation of mobile scenarios for informal learning activities such as field trips. The specific added value lies in the generality of our solution. The mobile application has been evaluated with overall positive results. We have also been able to show that students themselves can be authors of such guided tours. This can be seen as kind of “learning by teaching”, which is a new combination with mobile learning.

The evaluation has shown the convenience of using simple and cheap printouts of QR codes for location identification. The students’ feedback provided many new ideas and extensions to the presented approach. We are currently already working on a new version that will allow for richer (and more complex) scenario content (multiple pages per location, videos, audio and HTML-based embedded pages), reuse of QR codes for multiple scenarios and a more flexible quiz editor also supporting open questions with free text input. Furthermore, we plan to improve the support for indoor navigation between locations by integrating custom maps (e.g., of a museum). This will still not provide a real navigation but at least support the user to find his or her way inside the building. Future activities will extend the Mobilogue system to support data collection during the field trip and present the results for follow-up activities and reflection in a web-based environment.

Beside the technical extensions, we are on the one hand developing more scenarios (outside the museum context) to prove the general approach of Mobilogue. On the other hand, we are working out the details of a second evaluation with a more complex scenario. We included pre- and post-tests to measure the knowledge of the students about historic topics presented in the exhibition and topics explicitly covered by the guided scenario. First results show that there is a significant knowledge gain in the topics covered by the mobile guide and only little knowledge gain in other topics. The next step is to measure the knowledge gain of the authoring students and to compare the differences concerning the side topics. Finally, the Mobilogue framework is available for testing under <http://mobilogue.collide.info>.

ACKNOWLEDGMENTS

We want to thank the 10th grade class of Dr. Markus Kuhn from the Elsa Brändström Gymnasium Oberhausen, Germany for participation in the study of the authoring tool and the creation of the guide prototype for the usability evaluation. We further want to thank the TOP SECRET museum in Oberhausen, Germany, for the successful cooperation.

REFERENCES

- Bahl, P., & Padmanabhan, V. N. (2000). RADAR: an in-building RF-based user location and tracking system. 2nd Proceedings IEEE INFOCOM 2000 Conference on Computer Communications. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies Cat No00CH37064 775–784. IEEE.
- Ballagas, R., Walz, S., & Borchers, J. (2006). REXplorer: A Pervasive Spell-Casting Game for Tourists as Social Software. *CHI 2006*.
- Botturi, L., Inversini, A., & Maria, A. Di. (2009). The City Treasure: Mobile Games for Learning Cultural Heritage. In J. Trant & D. Bearman (Eds.), *Museums and the Web 2010 Proceedings*. Toronto: Archives & Museum Informatics.
- DeWitt, J., & Storksdieck, M. (2008). A Short Review of School Field Trips: Key Findings from the Past and Implications for the Future. *Visitor Studies*, 11(2), 181–197.
- El-Bishouty, M. M., Ogata, H., & Yano, Y. (2007). PERKAM: Personalized knowledge awareness map for computer supported ubiquitous learning. *EDUCATIONAL TECHNOLOGY SOCIETY*, 10(3), 122–134.
- Fielding, R. T. (2000). *Architectural Styles and the Design of Network-based Software Architectures*. (R. N. Taylor, Ed.) Building. Citeseer.
- Föckler, P., Zeidler, T., Brombach, B., Bruns, E., & Bimber, O. (2005). PhoneGuide: museum guidance supported by on-device object recognition on mobile phones. *Proceedings of the 4th international conference on Mobile and ubiquitous multimedia* (pp. 3–10). ACM.
- Gassner, K. (2003). *Diskussionen als Szenario zur Ko-Konstruktion von Wissen mit visuellen Sprachen*. Universität Duisburg-Essen.
- Giemza, A., Verheyen, P., & Hoppe, H. U. (2012). Challenges in Scaling Mobile Learning Applications: The Example of Quizzer. *2012 IEEE Seventh International Conference on Wireless, Mobile and Ubiquitous Technology in Education* (pp. 287–291). IEEE.
- GoMo Learning. (August 2013). Retrieved from <http://epiclearninggroup.com/uk/platforms/gomo-learning-authoring-tool/>
- Henderson, S., & Yeow, J. (2012). iPad in Education: A Case Study of iPad Adoption and Use in a Primary School. *2012 45th Hawaii International Conference on System Sciences*, 78–87.
- Kisiel, J. (2005). Understanding elementary teacher motivations for science fieldtrips. *Science Education*, 89(6), 936–955.
- Kohen-Vacs, D., Ronen, M., & Cohen, S. (2012). Mobile Treasure Hunt Games for Outdoor Learning. *IEEE Technical Committee on Learning Technology*, 14(4), 24–26.
- Mody, A., Akram, M., Rony, K., Aman, M. S., & Kamoua, R. Enhancing user experience at museums using smart phones with RFID. 2009 IEEE Long Island Systems Applications and Technology Conference 1–5 (2009). IEEE.
- Pinkwart, N., Hoppe, U., & Gassner, K. Integration of domain-specific elements into visual language based collaborative environments. *Proceedings Seventh International Workshop on Groupware CRIWG 2001* 142–147 (2001). IEEE Comput. Soc.
- Ruf, B., Kokiopoulou, E., & Detyniecki, M. (2008). Mobile museum guide based on fast SIFT recognition. (M. Detyniecki, U. Leiner, & A. Nürnberger, Eds.) *6th International Workshop on Adaptive Multimedia Retrieval*, 5811, 170–183.
- Sharples, M., Taylor, J., & Vavoula, G. (2005). Towards a Theory of Mobile Learning. (H. Van Der Merwe & T. Brown, Eds.) *Mind*, 1(1), 1–9.
- Spikol, D., & Milrad, M. (2008). Physical activities and playful learning using mobile games. *Research and Practice in Technology Enhanced Learning*, 03(03), 275–295.
- Vavoula, G. N., Sharples, M., Rudman, P., Meek, J., & Lonsdale, P. (2009). Myartspace: Design and evaluation of support for learning with multimedia phones between classrooms and museums. *Computers & Education*, 53(2), 286–299.
- Weinbrenner, S. (2012). *SQLSpaces – A Platform for Flexible Language-Heterogeneous Multi-Agent Systems* (p. 190). München: Dr. Hut.
- Yiannoutsou, N., Papadimitriou, I., Komis, V., & Avouris, N. (2009). Playing with ” Museum Exhibits : Designing Educational Games Mediated by Mobile Technology. *Context*, 6–9.