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SMARTGEO – MOBILE LEARNING IN GEOGRAPHY EDUCATION

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Abstract

We all have them and they are omnipresent in our everyday lives: smartphones and a wide range of applications. Apart from communication and information these powerful devices provide enormous resources for learning in and about our local and global environment. Integrating GPS tools they even link information with spatial patterns and allow us to analyze and understand relations and locations in the context of spaces and places. In this context augmented reality is supposed to be highly effective to enhance the development of various geographical competences. Based on best practice examples developed at Freiburg University of Education we have initiated some empirical research projects to learn how effective the implementation of Smartphones in the teaching and learning process is and how to improve the tools. The paper presents a deeper insight into the use of smartphone applications for education and two case studies: 1. QR-code based learning environments developed together with students and professional media designers. This study provides insights into some preliminary empirical findings evaluating the applications in the context of Geography learning and 2. Students create their own apps. These apps do not focus on school and university students only. The applications promote Geography in the wider context for different target groups like refugees, children or seniors in the sense of *Service Learning*.

Keywords: *Mobile learning, QR-Codes, Apps, environmental education.*

1. INTRODUCTION: MOBILE LEARNING: SMARTPHONES; TABLETS AND TABLETS IN EDUCATIONAL CONTEXTS

The potential of mobile, digital devices such as smartphones and tablets is more and more evident in the most recent developments, however empirical research dealing with the effectiveness is still rather limited.

A wide range of geography and science related apps for smartphones already offer versatile applications such as navigation, orientation, information, communication, tracking, GIS, augmented reality and a lot more. The multi-functional nature of the digital devices and their portability are the main strengths for learning (Welsh et al., 2015). Furthermore mobile learning provides learning facilities anywhere and at any time (Burghardt et al., 2016). Thus the integration of portable devices into the learning process allows a wide range of options for teaching space related phenomena and, according to Medzini (2014), "these devices can enrich learning by providing authentic and contextual learning conditions".

In addition Welsh et al. state that staff and students should experiment in exploring the wide range of possibilities (Welsh et al., 2012). While traditional forms of computer based e-learning offer spatially limited options, mobile learning opens new potential for outdoor learning in particular. In our educational programs we are experimenting with QR-code guided geotrails. Additionally our students generate self-made apps which not only allow for the further development of their media competences, but also to critically reflect their knowledge acquisition on a metacognitive level. By developing context embedded smartphone applications they are collecting, selecting and analyzing all kinds of spatial information which widens their cognitive competences as well.

Mobile phones are the most widely used devices. The results of a survey of 1200 teenager in Germany from 2015 showed some relevant results: "mobile phones (mostly smartphones), computers or laptops, televisions and internet access (...) were available in practically all families" (Medienpädagogischer Forschungsverbund Südwest 2015, p. 52). 98% of the 12- to 19-year-olds therefore have a mobile phone (92% smartphones) and applications are indispensable and determine the everyday life of the pupils mainly for communication and entertainment. However, using geographic applications is rather rare: only 16% navigated with digital maps (Medienpädagogischer Forschungsverbund Südwest 2015, p. 53). About half of the teachers indicated that they wanted to use new media, but pointed out problems with the equipment, the effort and technical knowledge and some of them are afraid of negative effects on their teaching (Bitkom Research 2015, p. 11). It can be said that smartphones play a very important role in the leisure time of pupils, but are little used in the classroom.

Meanwhile media competence is seen as one of the most important key competences of our time. Furthermore, according to experts, the "medium" app will gain importance in teaching in the coming years (MMB Institut 2011, p. 5). Entering Higher Education most undergraduate students have a smartphone or a mobile device (Welsh & France, 2012). An undergraduate student study found that many students who own smartphones are "largely unaware of their potential to support learning" but importantly, found that they are, "interested in and open to the potential as they become familiar with the possibilities" (Woodcock et al., 2012). Furthermore students can make clear links between the use of a variety of mobile apps and graduate attribute development (France et al., 2016). According to what we have observed the integration of mobile phones into educational contexts is highly motivating for learners and educators likewise.

The use of mobile devices can be differentiated into three formats: communication, information reception and information production.

Firstly you can use mobile devices for simple reception such as information gathering or descriptive searches, or, as Medzini (2014) calls it "information consumption". It is said that the enormous advantage is that the information is accessible anytime and anywhere (Burghardt, 2014; Medzini, 2014) but the reality in educational contexts often confronts educators and learners with obstacles. Not all students have access to unlimited data and there are still regions without any net coverage.

The information that can be received can either be provided by teachers or unfiltered by search engines such as Google or Explorer. Easy access of information does not mean immediate development of knowledge; many restrictions hamper the learning process. According to what we have observed in our projects exactly the opposite is the case: the easier the information can be found the less effort students make to understand and analyse the facts they are dealing with. Apart from deficits in critical reflection a thorough cognitive penetration may not take place. Another problem is the reliability of what the Internet offers.

Many students still tend to use material without clearly traceable sources thus a danger of manipulation exists. However being aware of the problems is a way to avoid the risks and to use the material provided in a conscious manner.

Apart from factual information about geographic locations, place settings, spatial distribution, technical or scientific backgrounds, statistical data, historic facts and many more, mobile devices provide relatively easy access to thematic maps related to your specific location. In combination with the integrated navigation software and GPS receivers learners are supposed to develop spatial competences, which implies that orientation improves and their map reading competences are widened. But students do not look around anymore as artificial voices explain the route they take. Consequently a tendency of real environment ignorance can be observed, leading to obvious deficits in spatial orientation without mobile devices. According to what we have learned from our students the perception of landmarks, crossroads or buildings is reduced compared to traditional methods of map supported pathfinding.

Secondly mobile devices may be integrated into the learning process to produce information (Medzini 2014) which is cognitively more challenging. The production of information may include measuring, map creation, surveying or even the development of specific smart phone applications. However, the most basic ways to involve mobile devices are simple documentations using camera, geo-tagging functions or text tools.

Based either on self-made information or supported by external sources, augmented realities can be created. Following Sharma (2014) augmented reality is the "*superimposing of elements by computer-generated sensory devices such as video, GPS data or graphics over the real world environment*". Based on the identification of the individual location or steered by displayed QR codes versatile information can be embedded into life contexts blurring the borders between virtuality and reality. Integrating sliders into smartphone apps is a good example of how to document the potential of augmented realities, allowing the observer to compare what he or she sees with historic images. By comparing real objects with virtual documents cognitive processes are initiated leading to a better understanding of developments and spatial processes. Apart from the positive effects the implementation of augmented reality has, learners and educators should be aware of the risk to become manipulated. Integrated hidden advertisements and embedded product placements are only the smallest dimension of the problem.

Teaching space related phenomena thus does not only mean describing what can be seen (the obvious) or analysing contexts, systems, hidden structures and meanings, it also implies the exchange of information. The proliferation of knowledge, which is the result of the digested information, may also be based on smartphones. In addition to the more traditional ways of communication such as e-mail or SMS all kinds of social media like Facebook, Instagram, Skype or WhatsApp provide channels to share the information. Larger datasets can be stored in clouds for common usage.

Technically there seem to be no restrictions. Mobile learning has a great potential to support the individual formation of knowledge based on data collection, intellectual digestion of manifold information and communication. From a didactical point of view there are certain risks to be taken into account. Those risks are not primarily of a technical nature, risks are related to the content and the way facts are provided. It is in the responsibility of the educators to create a distanced critical awareness not to be misguided by manipulation.

1.2 Background: Creating innovative learning environments

Smartphones are interesting for the vast majority of people and offer an innovative and interactive holistic media tool. The prevailing positive attitude is supports the idea of using smartphones for teaching and learning, particularly during field trips and other outdoor educational settings. Employing the technical device seems to generate a kind of intrinsic motivation which opens the cognitive door to investigate and understand "real" world phenomena. As said before, the margin between reality and virtuality can no more be identified exactly, in addition what learners perceive is individual and subjective. The user's attention is always focussed on preselected aspects. Critical reflection of the provided information is a fundamental momentum.

Mobile learning, as the name implies, allows a nearly unlimited locational flexibility and can be related to manifold contextual frameworks (Kingston, 2012). Thus even the planning process of a learning activity may shift from the educator into the hands of the learner. Depending on your teaching objectives and the target group more open or more closed learning arrangements may be created. The options cover a wide range and reach from predefined mobile device based documentation or orientation tasks and context based information collection (reproductive, receptive) to open exploration tasks. Even the individual development of smartphone apps by single students or groups is a likely option. Particularly experienced learners with a well-developed technical understanding and a foundation of contextual pre-knowledge are in favour of practical hands on activities or in other words to use mobile devices as a creative tool (productive, constructive). In what we have observed student centred knowledge production dramatically increases learners' awareness for and understanding of phenomena, structures, causes and effects. In particular collecting, analysing and the selection of information enlarge the cognitive competences of learners.

Collecting information or making use of existing resources such as QR-Code based Geotrails is more receptive and does not necessarily require specific technical knowledge. Reception in the context of mobile learning does not mean to remain on a descriptive level but needs to be supported by additional exploration or observation tasks provided by the educator. As in all learning processes the complexity of topics, tasks and applied methods may be gradually increased in accordance with the learners` abilities.

Some overall advantages of mobile devices are the high potentials for differentiation and individualisation (Burghardt, 2016). Student´s pre-knowledge and existing spatial concepts are individual starting points for active knowledge construction in the field. Mobile devices are supportive and may invite and motivate students, but seen from a learning psychological perspective they are not more than an effective multimedia tool. However, in addition to their complex potential to provide and to produce information mobile devices have the capacity to stimulate all perception channels and thus provide learning opportunities for different learner types. A specific characteristic in this context is to involve students into all kinds of environment related activities, be it observation, measuring or orientation. As mobile devices offer the potential for communication they can be described as triple interactive tools. On the one hand student-environment interaction can be initiated, on the other hand information exchange from student to student and other consumers is possible. In addition learners interact with their mobile devices.

A unique and highly appreciable functionality is the option to superimpose "elements by computer generated sensory devices such as video, GPS data or graphics over the real world environment" (Sharma, 2014), the reality is partly mediated and augmented[1]. Embedding and adding further information into specific spatial contexts is thus described as augmented reality, which is based on geo tagging. As stated by Sharma (2014) the "*information can be displayed into users real-world view more cognition effectively*". According to what we learn from our research results this does not happen automatically but depends on a number of

[1] augere (lat.) – to increase

additional factors. In particular cognitive preparedness and focussed students' interests are essential for active knowledge generation beyond simple reception and the accumulation of meaningless declarative information. As discussed above augmented outdoor learning always needs students' preparedness to take on a critical perspective towards the additionally provided information.

Learning about and in spatial contexts on different scales is essential for geography learning which is a highly complex task, rather ambitious and needs specific methodological approaches. According to the DGFG (2014) Geography is a subject integrating sciences and social studies and the overall intention is to provide competences for understanding natural and social interrelations in spatial and systematic contexts. As the perspective is on real world phenomena, problem based teaching is one pedagogical choice. SmartGEO intends to integrate the use of smartphones into geography education to develop various subject specific key competences. Mobile outdoor learning has the capacity to combine the achievement of subject-specific knowledge (understanding space and place, interrelations and systems etc.), with spatial orientation (real world orientation, map reading and construction, spatial perceptions) and the collection of data based on subject specific technologies (GIS, GPS). Furthermore communication, evaluation and taking action, which are also defined as key competences by the DGFG (2014) is stimulated. With regard to the fact that mobile learning can be organised individually, self-reflectively and critically it becomes obvious that learners are offered options to understand spatial contexts as constructed and intentionally defined. That is why m-learning strategies provide the potential to "negotiate" between different geographical concepts such as space and place.

2. A QR-CODE BASED GEOTRAIL: DISCOVER THE NATURAL AND CULTURAL HERITAGE OF THE VILLAGE OF DENZLINGEN

2.1 The concept: Interpretive signs

The geotrail was opened in 2015 after a long period of development and testing combining the principles of traditional information signs with elements of web-based mobile learning. At the moment (2016) 12 displays which are located in and around the village provide information about natural and cultural phenomena that can be observed. The topics vary from different aspects of geomorphology, climate, settlement patterns, historic buildings and sites, just to name a few examples (Figure 1).

Figure 1. Overview Geotrail Denzlingen

The signs invite the visitor with a motivating heading and a very short informative text. In addition the visitor can use the QR code to learn more about the location (Figure 2).

Figure 2. QR Code Spurensuche Denzlingen

Once connected with the website the attention is focused on information linked to the observed phenomena. Following Bloom´s taxonomy the information structure is hierarchically organized (Bloom, 1999). The information on the physical sign and on the first interactive level accessed via mobile devices is attractive, motivating, question raising but remains on a descriptive and informative level. In case the visitor wants to have more detailed information he or she can enter an interactive level offering video sequences, quiz elements, interactive questions or the invitation to observe the landscape or historic sites. All in all the QR-codes allow access to 70 different information sources (texts, graphics etc.) and more than 100 minutes of video sequences and animations. The third level, which is much more complex, can be called the expert level. Here the visitor finds essays, statistics, links and other academic material. In addition all locations are embedded into an orientation system, maps and GPS coordinates are provided and if wished the user is guided from one location to the other automatically. The texts can be read by the visitor on his own or listened to (automated voice output). Even if you do not have the option to walk around or visit the locations physically you can easily access the information online from home. All texts are presented in five European languages (English, German, Polish, Italian and French).

Within the next months the second phase of the project will be realized and another 12 signs, particularly dealing with historic objects like mills, churches or the traditional train station are going to be erected. Apart from the internal structure of each location, different signs can be thematically linked individually according to the intentions of the visitor. As described in the previous chapter one big advantage is the combination of what can be observed as a real world phenomenon and additional background information accessible via mobile devices. As the media concept is based on interactivity the visitor's attention is focused on particularly relevant aspects that can be examined in the field. The integration of augmented reality allows comparisons and to understand changes in spatial patterns over the time. In addition it is possible to provide material for different age groups. For more information visit the geotrail website and try the interactive information signs online: http://www.spurensuchen-denzlingen.de/.

2.2 Preliminary Findings

From the very beginning of the conception and the development of the first signs, the process was accompanied by intense evaluation, testing and feedback gathering and since the opening of the geotrail educational output and practicability are permanently evaluated. On the one hand qualitative research is applied; on the other hand various quantitative aspects are monitored. To learn more about the concept, the applied methods and strengths and weaknesses, we have tested the geotrail with student groups from local universities (n = 29) and our local high school (n = 21). A key element of our research was a questionnaire-based evaluation including space for free feedback and closed questions. As some of the respondents are already well-educated student teachers, a number of helpful comments and recommendations for improvements have been collected. As a matter of fact, a number of improvements and changes were already made. The questionnaire intends to provide information about the visitors` expectations (Figure 3) and their specific interests and priorities.

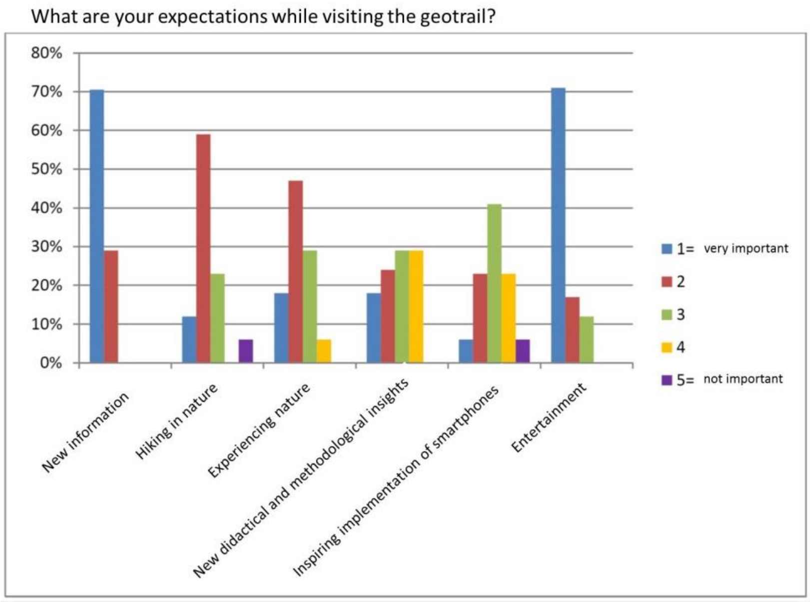


Figure 3. Expectations Spurensuche Denzlingen, n = 29

All signs are evaluated separately, analyzed didactically and individually commented. To evaluate the locations a detailed structure was provided and marks (from 1 = very good to 6 = very poor) were requested for the following aspects: quality of information (average result = 1.5), differentiation (average result = 1.8), interactivity (average result = 2.1), technical and media design (average result = 1.6), selected location (average result = 1.8) and if the provided information is closely linked to the specific location (average result = 1.7). As the results document, the respondents provide an overall positive feedback.

Furthermore we ran Google statistics which enables information to be gathered about the age and gender of the visitors. It is exactly documented how much time people have spent at the different displays and which information level they have accessed. It became obvious that some locations seem to be more interesting and better accessible than others. Interestingly the geotrail has a number of returning visitors not only from regional contexts but from abroad as well. These have visited the trail virtually from their desktop PC at home.

All in all the geotrail has received a highly positive evaluation, visitors particularly stress the high interactivity, the information structure and the motivating character. The implementation of augmented realities was discussed and regarded to be adequately applied. According to our findings the vast majority of respondents have widened their cognitive competences sustainably. One particular reason mentioned was the fact that the provided information was not only presented as isolated factual knowledge but interactively developed at the specific location. As our evaluators describe “*there was a feeling of doing some little research in the field, the tool asks questions and invites visitors to explore the environment. In addition valuable background information is made available*.” Additionally it is stated that “*the fun factor is really high and videos, animations, images, sliders, maps and texts are very motivating to learn more about the environment and the history*.” However, some technical restrictions such as limited data volume, limited network coverage and high battery consumption capacity became obvious.

3. FROM APP-USERS TO APP-CREATORS

3.1 The concept: Intepretive apps

The shift from app-users to app-content-developers opens up a completely new perspective for the learner. Students from two universities in Freiburg and a school class tried this approach and prepared their own applications cooperatively and collaboratively (Figure 4). The target groups involved with these applications have been other students as well as tourists, senior citizens, refugees, etc. The work was carried out in close cooperation with lecturers and media scientists.

Source: Photo by Michael Kuhn

Figure 4. Student with self-generated Application

Quality assurance was achieved through the integration of the methodological-didactic approach *Heritage Interpretation (HI). HI* describes a contemporary and professional mediation of natural and cultural phenomena in its social and spatial context. The approach *HI* was developed in the National Parks in the USA to communicate the natural and cultural heritage to visitors with the major goal of connecting people to nature (Tilden, 2008). *HI* is defined by the *National Association for Heritage Interpretation* in the US as “*a mission-based communication process that forges emotional and intellectual connections between the interests of the audience and the meanings inherent in the resource*.” (NAI, 2016). This approach has already been established in the English-speaking world not only in national parks but also at UNESCO World Heritage Sites, in museums or science centers and is being taught and researched in appropriate courses and master programs at universities. Until now, *HI* is only poorly present in Europe, but in 2010 *Interpret Europe* was founded at the University of Freiburg aiming to support sustainable tourism, lifelong learning and the protection of natural and cultural heritage in Europe (Interpret Europe, 2016). Experiences of the past years also showed a huge potential for *HI* in geography learning. Natural or cultural phenomena were linked to the everyday lives of the learners and provide a personal and emotional access. This effective connection leads to a deeper understanding (Beck and Cable, 2015: p. 28).

3.2 How to create application-content?

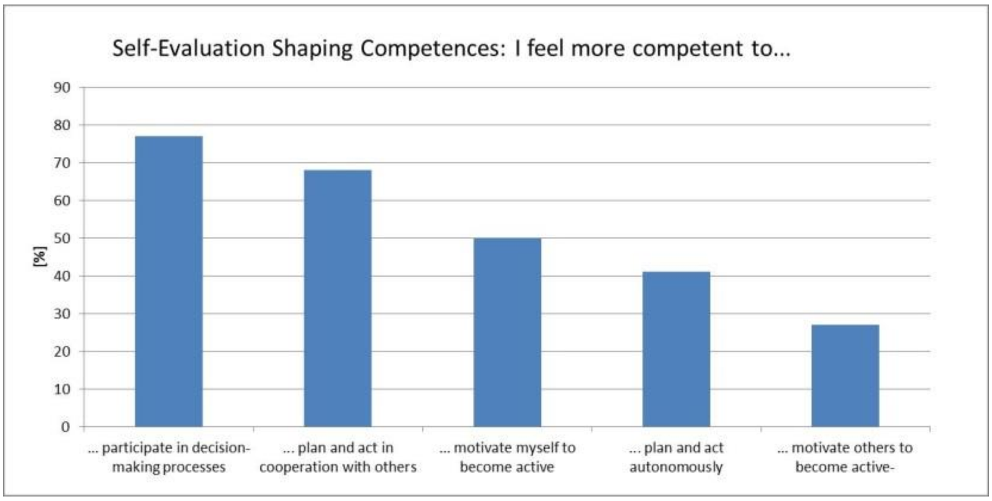
Field work is "*the heart of geography*" (Falk 2015: p. 150) and forms the basis for the development of applications. Participants generated the specific characteristics of a region, city or geographical theme through a triangulation with field trips, current research results (literature survey) and expert interviews. The data obtained is subsequently translated into texts, audio files, short films and comparisons of historical with recent photos. Augmented reality is used for example to show the geological layers in the field.

The students edited the texts in an HTML editor. The content gets merged into a multimedia geographic information system. The apps include, on one hand, the geographic data with the coordinates of the points of interest (POI) and, on the other hand, the files which presents the contents related to the POI. As a geographic information system students used either ArcGIS or the free version QGIS and maintained their data in shapefiles. That GIS is a useful tool for documentation and learning is a well-documented fact (see Papafragkaki & Photis, 2014; Estes, 2011, Barnikel, 2015; Falk, 2003a, 2006). Even without additional programming costs, students or pupils can generate apps themselves simply with story maps from ArcGIS (http://storymaps.arcgis.com/en) or completely free of charge with Actionbound (see www.actionbound.de).

Our course was funded by the Instructional Development Award (IDA) of the University of Freiburg in 2015. The provided financial support allowed us to built-up our own construction kit for the development of the applications.

3.3 Why create applications?

Students as app-creators move from a purely receptive attitude into the role of active knowledge mediators and their shaping competences are decisively promoted (Figure 5). They developed the ability to present complex content in a simple, but scientifically correct manner, so that a person who is unfamiliar with the subject perceives the interpreted topic as interesting and inspiring. Students and pupils dealt with particularly glocal themes supporting the development of a deeper geographical understanding (Fögele, 2016). Furthermore students learned to gather, interpret, classify and present interesting contents in a geographical information system.



Source: Chatel modified Roth 2016, n = 22

Figure 5. Increasing Shaping Competences.

At the end the students tested their own product to create an optimized and high-quality app (Ham & Weiler, 2006; Savage & James, 2001) which is the basis for further empirical social research. This includes, on the one hand, an expert check to scientifically verify the content and, on the other hand, the check of the functionality with the target group for which the app has been developed. By evaluating the apps, recommendations and quality criteria for apps can also be developed and tested in practice according to the *Heritage Interpretation* approach.

Additionally the applications provide added value for the general public in the sense of *Service Learning* by uploading them into the Playstore (see FREIBLICK). *Service learning* refers to a process enabling students to transfer their knowledge from local projects into practice. Furthermore the information is made accessible for the public. We found that locals and tourists like to be linked to their surroundings and to be informed about the natural and cultural phenomena, the population enjoys interpretations in a sense of lifelong learning (Chatel-Messer, 2015). Now citizens can use the apps to explore their surroundings and learn through well-prepared background interpretation. For students this *Service Learning* approach has proved to be extremely motivating. For pupils it may help to strengthen their regional identity and increase the appreciation of their regional natural and cultural heritage. Having developed an app about their hometown, 77% of the pupils stated that they feel more related to their hometown (n = 22; Roth, 2016). By understanding and experiencing carefully chosen geoscientific contents, students awareness about the value of a region and the need for protection increases (Kreisel, 2003: p. 5). T. Ludwig calls *Heritage Interpretation* the most successful educational concept in the world of short-term education (Ludwig, 2012: p. 12) and studies prove sustainable behavioral changes with regard to the protection of “phenomena” (Tubb, 2003: p. 476). Furthermore the *Spatial Citizenship* approach (Schulz et al., 2015) is fully met by this project. It´s main goal is “*using digital geo-media to promote self-responsibility in social participatory processes*”. The apps provide for example added value for the citizen of Freiburg by an app-tour about critical consumption or for the integration of refugees in Freiburg and the surrounding area. At the end a critically reflective discussion with the medium is essential.

4. CONCLUSIONS

Smartphones are an integral part of students´ lives and an immense resource for learning about local and global phenomena. We found that pupils, students and also the general public are interested in achieving deeper insights into their living environments based on reliable information. As multimedia-tools smartphones and other mobile devices can support outdoor learning activities and teaching arrangements. Apart from the fact that smartphones are still very motivating for students they offer a vast range of opportunities to mediate between subjective realities and constructed information provided electronically. As beneficial as the implementation of smartphones may be for the learning process and the understanding of environmental and historical structures, there are dangers in a non-critical use of provided data. In the context of responsible learning educators have to make sure that students and pupils are aware of the fact that any media provided information is set up intentionally and may have the potential for manipulation. Critical reflection is of fundamental importance. In future the settings may further develop as technical solutions become more and more specified, complex and user friendly. The implementation of QR-codes as gate openers from reality to virtuality in combination with a modern and innovative geotrail is very promising. According to what we learn from our research projects the vast majority of visitors develop a positive attitude towards this kind of mobile learning.

The combination of outdoor experiences and exploration with theoretical knowledge supports the development of cognitive competences and trains technical skills. Provided that GPS and map resources are used this QR-code based geotrail allows the development of the competence of spatial orientation which is a geographical key competence. However visiting a geotrail is more than the entertaining reception of factual knowledge, it may lead to a deeper understanding of landscapes and cultures - a process which is best described in terms of Heritage Interpretation. As we understand it Heritage Interpretation is a very useful approach to communicate geographical contents to learners. Creating their own applications motivates students to generate interesting texts, compile relevant photos, films, audio files, augmented reality or sliders. To produce these app-contents students need to have a deep understanding of the described and observed phenomena. They are learning before and while developing the applications and consequently they also develop their shaping competences. The applications can be downloaded in Playstore, thus this innovative educational format provides an important contribution to promote geography to the general public. To further develop the innovative potential, all processes and results are consistently evaluated and modified based on empirical evidence.

Mobile learning offers numerous opportunities for learning in and about different geographies in different spatial and cultural contexts. The methodological options are huge and only limited by insufficient network coverage and lack of data volume. Provided that smartphone supported outdoor learning is well-prepared and didactically reflected, both teachers and learners may benefit. They can enjoy their subject in real-world contexts. In addition, creating new contents and preparing the information for publication is particularly challenging but also quite motivating. There is still a lot of research work to be done to gain better understanding of e-learning and mobile learning related learning psychological phenomena.

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