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Location-based games with smartphones – developing a toolbox for educators

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Abstract

Location-based games for educational purposes provide a link between content and its real-life relevance in a physical environment. The potential of mobile, location-based activities for authentic learning is well known, but the technological and organizational barriers for educational staff still exist. There is a need for easy-to-use tools to facilitate the creation of playful location-based mobile learning activities.Within the MILE project (move-interact-learn-eat), a transdisciplinary team consisting of educational experts in the field of outdoor education, in nutrition and consumer education as well computer scientists developed an authoring system for location-based games, the MILE Designer. This authoring system provides several formats of tasks that can easily be adapted and each task is located intuitively using a simple map as interface. Several tasks are combined to an educational geogame for a native smartphone app. This paper describes the relevant theoretical background and the transdisciplinary development process. The MILE Designer was formatively evaluated in a participatory observation and in focus group discussions. The results of this evaluation process are presented and further educational implications are discussed.

Keywords: Location-based game, learning game design model.

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1. Introduction

Mobile devices are personal assistants for most adolescents and adults today (JIM 2015; Common Sense Census 2015) and their potential for lifelong, ubiquitous learning is undoubted (Brown, 2010; Clough, Jones, McAndrew & Scanlon, 2008; Frohberg, Goth & Schwabe, 2009; Hsiao, Lin, Feng & Li, 2010; Pachler, Bachmair & Cook, 2010; Specht, Ebner & Locker, 2013) Beneath offering mobile learning opportunities smartphones allow for location-based learning activities that help to transform a physical space into a personally relevant place (cf. Harrison & Dourish, 1996, Dourish, 2006).

In several domains mobile devices are successfully used to support knowledge acquisition(Chang, Chen & Hsu, 2011; Huang, Huang & Tschopp, 2010; Perry & Klopfer, 2014; Ruchter, Klar & Geiger, 2010; Shih, Chuang & Hwang, 2010) , motivation and interest (Heimonen et al., 2013; Lai, Yang, Chen, Ho & Chan, 2007; Ruchter, Klar &Geiger, 2010), attitudes and awareness (Schaal, GrUbmeyer & Matt, 2012; Uzunboylu, Cavus & Ercag, 2009) during location-based, authentic learning.

Authentic learning is focused on real-world problems and their solutions, it provides problem-based, collaborative, reflective activities and it is inherently multi-, trans- or interdisciplinary (cf. Lave & Wenger, 1991; CTGV, 1993). During mobile, location-based activities learners are guided to different places that are relevant for the topic and that allocate opportunities to interact with the environment. Mobile devices such as smartphones and tablets then offer the place-specific information, they can be used to retain impressions (e.g. audio, photo, video), to share them and thus they allow different ways of direct and indirect communication. Learners are asked to apply this information and knowledge to solve tasks in the field instead of just consuming it (Frohberg et al., 2009). The learners autonomously discover a site supported by an adequately structured mobile learning activity that can be - according to Ryan and Deci (2000) - a way to promote self-determination in an educational setting.

Mobile games played on smartphones or tablets are popular amongst adolescents, the American Common Sense Census (2015) shows that at least one third of the teens respectively every second tween plays every day. Location-based games, so called “geogames“ (Schlieder, 2014), are played in the physical space and locomotion is part of the activities. Geogames combine location- and game based learning, the players’ geographical position is part of the narrative and the game flow (de Souza e Silva, 2009; von Borries, Walz & Bottger, 2007). Geogames are conceptually grounded in the theoretical framework of Digital Game-based Learning (DGBL) that combines playing as an active form of entertainment and knowledge acquisition (Hamari, Keronen & Alha, 2015; Kerres & Borman, 2009; Prensky, 2001). It is intended to captivate the players’ attention and to use the game-related enjoyment as a starting point for learning processes or to increase situational interest or topic-related awareness and attitudes (Schaal, Schaal & Lude, 2015).

The potential of mobile, location- and game-based learning activities for authentic learning is evident, but (technological) barriers for educational staff still exist (Ketelhut & Schifter, 2012; Marsi-Schottmann & George, 2014; Wright & Parchoma, 2011). Schlieder (2014) as well as Pirker and colleagues (2014) point out that general findings from game design research should be part of educational applications for location-based learning and playful learning experiences. This is a challenge for educators, educational designers and computer scientists to be solved collaboratively. On the one hand, several models and frameworks for educational game design already exist (Ardito et al., 2010; Baggetun, 2009; Chamberlin, Trespalacios & Gallagher, 2012; Hirumi, Appelman, Rieber & Van Eck, 2010; McMahon, 2008) and most of them highlight the need for transdisciplinary collaboration. On the other hand recent educational game design processes are reported to be difficult due to the experts’ different academic background, theoretical foundation and finally to the specific language of the involved disciplines (Hirumi et al., 2010; Kirkley, Kirkley & Heneghan, 2007). Chamberlin and colleagues (2014) present a learning games design model that differentiates three phases of educational games development:

I. Pre-development: A consortium of game developers and content experts start together with a broad educational objective before engaging in immersion: game developers learn about the content and the educational implementation, the content experts experience different already existing learning games. Finally, the consortium refines the objectives, prepares design documents and creates prototypes.

II. Development: The prototypes are stepwise improved using a multi-stage formative evaluation circle with the participation of the development consortium and the target users and relevant gatekeepers.

III. Final stages: Summative evaluations are conducted with the final game and a larger audience is involved. The results are used for a final revision of the learning game.

The content for this paper is derived from nutrition and consumer sciences. Most young people in Western societies are merely eating as consumers with little knowledge about the origin of their food (Bartsch, 2008; Dreblow & Schonheit, 2010). But especially the awareness of cultural and natural resources of food production is an important objective of nutrition and consumer education (Bartsch, 2015; Heseker, Schlegel-Matthies, Heindl & Methfessel, 2005) as well as of an education for sustainable development (Lucas, Kok, Nilsson & Alkemade, 2014). At the same time, especially young people are intensive users of geo-enabled mobile phones and thus these devices with all their potential applications could be considered as mediators for authentic, location-based learning about food, food production and sustainability.

In this paper the MILE project (move-interact-learn-eat) is presented as an example for a collaborative, transdisciplinary development process of an authoring system combined with a geogame-app to facilitate a template-based online creation of mobile, location-based games in the domain of nutrition and consumer sciences for adolescents. First the design model and its theoretical background are outlined before the results of a formative evaluation of the authoring system using participatory observation and focus group discussions are described.

2. MILE (move-interact-learn-eat) – a transdisciplinary development project

The MILE project is funded by the Baden-Wuerttemberg State Ministry for Rural Areas and Consumer Protection (MLR) to develop a research-based online platform and authoring system allowing multipliers and educators to create geogames for adolescents. They act as multipliers out of school to foster nutrition and consumer education with the key objectives focusing a food production and consumer behavior that yields on a deeper understanding of regionally and seasonally grown agricultural products, responsible and sustainable value chains in adolescents' everyday life.

The MILE consortium consists of experts in the domain of nutrition and consumer sciences, biology and outdoor education as well as computer scientists. The theoretical framework for the design of educational location-based games is grounded on an empirical model for environmental competence (Roczen, Kaiser, Bogner & Wilson, 2014) that relates knowledge and attitudes to the tendency of environmental behavior. The authors conclude that a way to attain pro-environmentally competent people would be to increase knowledge and appreciation for nature (ibid., p. 17). Schaal and colleagues (2015) expanded this model for mobile, location-based games in the context of biodiversity: According to them appreciation might be positively influenced adding game-related enjoyment as well as situational interest by discovering content in an authentic, location-based game narrative. The MILE framework was adapted to the demands of the nutrition and consumer science content (see detailed in Schaal & Bartsch, 2015):

I. Attitudes, food preferences and daily routines are biographically developed factors (Bartsch & Methfessel, 2014) and they determine to a high extend consumer behaviors. In the MILE framework they are considered as personal prerequisites.

II. System knowledge about i.e. sustainable food production chains, action-related knowledge for responsible consumers' decisions and efficacy knowledge about the consequences of individuals' behavior determine the content of the MILE games.

III. Consumer behavior is considered to depend strongly on situational influences (Foxall & Yani-de-Soriano, 2005). A first step towards situational interest is to foster situated, authentic learning and to respect psychological basic needs. Both could be facilitated using a mobile, location-based game (cf. Erhel & Jamet, 2013; Li & Tsai, 2013).

IV. Enjoyment during the game experience could be a moderator for learning and a key for engagement in serious games (Allen, Crossley, Snow & McNamara, 2014; Ke, 2009). Tamborini and colleagues (2010) describe the game enjoyment depending on the perception of competence and autonomy as well as on social relatedness while playing.

These four areas for the design of mobile, location-based MILE games are challenging and further hints are encountered provided by the computer interface. This fact might put off a relevant proportion of educators in the field setting up their own playful activities for adolescents learning about food and food production.

The computer scientists of the Fraunhofer Institute FIT are partners in the MILE project and they have already developed and tested a web-based authoring system for scavenger-hunt-like location-based games (Wetzel, Blum, Jurgelionis & Oppermann, 2012). The MILE consortium adapted the learning games design model (Chamberlin, Trespalacios & Gallagher, 2014) to the purposes of location-based games considering previous findings related to location-based learning in environmental education (Schaal & Lude, 2015).

The transdisciplinary design process, the development of the MILE authoring system and of the MILE games together with the target users (MILE games for adolescents and authoring tools for educators) are described in the following section.

3. Methods & Material

3.1 Mobile, location-based games design process for MILE games

A native MILE-gaming-app presents the narrative, the gaming map with relevant landmarks is shown and it presents the location-based tasks that have to be accessed at the specific predefined GPS-position. The teams haunt all the position marked in the map and solve the given tasks, for every successful solution the receive rewards. Stemming from design-based research (Collins, 1992, DBRC, 2003, Barab & Squire, 2004) the general objective for the design of MILE games is twofold:

On the one hand the MILE games should provide playful activities for adolescents to discover different food- and consume-related problems immediately in an authentic context and in an everyday life setting (e.g. Food waste: what happens with unsold bread in the local bakeries - an interactive treasure hunt!). Therefore, the design process focuses on criteria for the creation of MILE games including adequately structured educational, location-based tasks at every distinct position. On the other hand, the MILE authoring system, the so-called MILE Designer, should be an easy-to-use web-based interface that allows educators and multipliers to create intuitively location-based games for smartphones. According to the Chamberlin et al.'s (2014) learning game design model the MILE consortium introduces three development steps to meet the two objectives:

Pre-development: Based on previous work (Bartsch & Schaal, 2014) the educational experts identified the objectives and described the theoretical framework for the MILE project (outlined in the section above). The content fosters the adolescents' awareness of local food and food production, the educational methodology focuses on research for the creation of location-based learning tasks (Schaal & Lude, 2015) and specific requirements are formulated. These are discussed with the computer scientist and the results are fixed in a requirements review (table 1).

Table 1. Requirements review for the (i) design of the authoring system and as (ii) use cases for the native MILE app

design level	target group	requirement
MILE. Designer authoring system	educator/ multiplier	- offline functionality - individual log-in - usability for step-by-step design process support - identification of relevant places and drag & drop-functionality to flag them in digital map - selection of different template-based task formats - upload of video, image, audio and text for the complete game and for each task to provide a game narrative - test mode in the app for live-testing
	developer	MILE game follows a location-based seek'n'find game mechanics similar to a Scavenger hunt. Templates for location-based tasks are defined: - single-choice and multiple-choice quizzes - GPS-single-choice quite: the possible solutions are geo-referenced and to select a solution the player must go at this place - matching and sorting tasks - free-text tasks - estimation tasks - find-place-tasks: picking-up a riddle and finding a specific place which is not indicated on the game map - speeding task: after arriving at the task position, another point has to be reached in a given time

native MILE-app	players	Players select a MILE game and download it, all data are stored in the MILE app. The player chooses a nickname and either starts a new game or continues an already existing one. After starting the game, the game narrative and the rules are presented before presenting the game map with the players' recent GPS-position and with all task locations. A task can be accomplished if the player reaches the specific location. Every location-specific task is introduced (via video, audio, text and/or image), after the solution the player receives immediately a feedback and the rewards (e.g. points). After the player has finished all tasks a game narrative closes the game session and the sum of points are sent to the MILE platform to rank the result.
	educator/ multiplier	directors' supervision mode: educator gets real-time positions of players (if data roaming is activated) during a session and text messages can be sent to all players.

I. Development phase: The first version of the MILE tools1.0 (MILE Designer and MILE app) was set up in March 2015. The formative evaluation was conducted in a three-step-procedure:

1. The first trials were set up in an educator-developer-team to assure a general functionality of the MILE Designer. The first MILE games were created collaboratively and field-tested. The educator-developer team consisted of two full professors (nutrition/home economics and nutrition- and consumer education, biology and biology education) and one graduated nutritional scientist from two universities of education, one computer scientist (group leader mixed and augmented reality solutions) and two developers of the Fraunhofer Institute FIT.

2. The MILE tools were revised and the MILE tools 1.1 were implemented into a focus group workshop and a participatory observation. The focus group was formed of educational and computer science experts, educators/multipliers in the field of nutrition science and pre-service teacher students. Parts of the MILE consortium moderated the focus group workshop, the educational researchers within the consortium observed and documented the process. The results were used to design the MILE tools version 2.0.

3. In spring 2015 two workshops for educational multipliers and pre-service-teachers lead to further implications for the (a) format of introduction to the MILE tools and for the design of a (b) final version 3.0 of the MILE tools.

II. Implementation and summative evaluation: The MILE tools 3.0 was introduced to several workshops for educators/multipliers. In this phase (a) the quality of the educators'/multipliers' MILE games is considered qualitatively via criteria-guided content analysis and (b) the outcomes (knowledge, motivation/interest, enjoyment, consumer behavior) on the players' level are assessed quantitatively using questionnaires and concept-mapping procedures. This is an ongoing research during spring/summer 2016 and the results will presented otherwise.

3.2 Participants

The focus group consisted of one developer, the educators team, three experienced pre-service teacher students and five educational multipliers (nutrition experts and multipliers in the service of the MLR).

The two workshops were conducted with (a) N=11 educational multipliers and (b) N=14 undergraduate pre-service teacher students (nutrition and consumer education).

3.3 Methods

In the focus group workshop two procedures were used:

1. Think-pair-share: The participants played a pre-defined MILE game and afterwards they created their own games in pairs with the MILE designer. Then the participants were asked to think about (a) the usability of the MILE app and the MILE designer, (b) the automated support during playing and during setting up the MILE game and (c) the support by the templates for location-based activities. The individual results were discussed in pairs, noted and finally shared in the focus group.

2. Structured, open-ended questions: Every participant was asked to give a written feed-back about (a) the game design, (b) the MILE game operation system, (c) the display and screen design of the MILE game, (d) the GPS services.

The workshop participants gave a structured feedback about (a) technological purposes of the MILE tools, (b) the usability of the tools and about (c) game-experience related perceptions.

4. Results

4.1 Focus group results

The results of the focus group discussions and the open questionnaires are outlined in the following table:

Table 2. Results of the focus group workshop (pooled data from discussion and open questionnaire, N=11 participants)

design area	tool or field	description
game design in the native MILE app	game flow	- seek'n'find game mechanics are highly appreciated - combination of mobile game and location-based task is perceived to be fruitful and engaging - different location-based tasks contribute to game enjoyment - gratification by collecting points increases enjoyment, time constraints decrease engagement in location-based tasks - narrative is important for game flow, video at the beginning and the end of the game are recommended

	functionality/ usability	- intuitive screen interface - GOOGLE-like map and the landmarks are known from other activities - positioning on the map and sensibility of the GPS function have to be improved → delayed - high differences of the reliability of the GPS positioning depending on devices - help/support function is needed - technical breakdowns
	location-based tasks	- different formats of activities and engagement increase enjoyment - explanation in text combined with audio/video is highly appreciated, but in (some) tasks has to be improved - open text questions are interesting, but difficult to fill out correctly - some tasks provide immediate feedback, should be given for every task - landmarks partially overlap the map and hinder orientation
MILE designer	functionality/ usability	- step-by-step and template-based design are highly appreciated → design process comprehensible and goal-oriented also for inexperienced users - usability of the MILE designer interface is easy-to-use - developers' terms are sometimes not familiar to educators and should be explained or adapted - pre-positioning of the single tasks' template landmarks should be not the same - interactive preview mode in the MILE designer is needed
	educational use	- MILE designer allows the design of games suitable for formal and informal educational purposes

	- design process could be also used for peer-to-peer activities

The suggestions were used for a revision of the MILE tools, especially the introduction of the game via video improved the game flow. Furthermore, balancing the accuracy of GPS positioning and the battery runtime was a task for the developers. Despite of the preview mode all revisions were realized for the MILE tools version 2.0

The subsequent workshops with educational multipliers and pre-service teachers showed that most of the technical purposes were revised successfully, but the accuracy of the GPS positioning differed dramatically between different devices. Thus it was recommended to use a diameter of the landmark of at least 20 meters and to highlight in the educators' workshops for the prerequisites to reach adequate GPS accuracy.

Furthermore it was highlighted to thoroughly pay attention to the explanation of the game mechanics, of the tasks and the gratification in the game as well as to identify relevant narratives specifically for the target group. The narrative and the rules, in the given examples, were highlighted to be clear and motivating. According to the German grading system (1 best, 6 worst grading) the participants graded the MILE tools 2.0 as good (grade 1,96).

Central feedback of the workshop participants was that they enjoyed – again – the combination of tasks in the "real environment" and mobile gaming. The game narrative and the location-based tasks were perceived to be engaging and suitable for playful learning. They praised the easy-to-use of the MILE tools and highlighted the MILE games for the following educational activities: (i) perfect way for informal learning for adolescents, (ii) fits location-based activities in several domains, (ii) combines nutrition and physical activity in an ideal way.

5. Discussion and conclusion

The results of the formative evaluation process indicated a successive improvement of the MILE tools and a high acceptance of the location-based games postulated by the educational multipliers in nutrition and consumer education. Iten and Petko (2014) conclude that serious games should rather be engaging than just being fun. The participants' feedback from the focus group and the workshops showed that this requirement was already met and it now would be interesting to do the last step of the learning game design model – the summative evaluation.

Anderson (2013) highlights that educational technology should somehow transform learning instead of just replacing or simply improving analogue media. As the MILE games were perceived as a fruitful combination of using mobile technology and experiential learning in the physical environment this requirement was met.

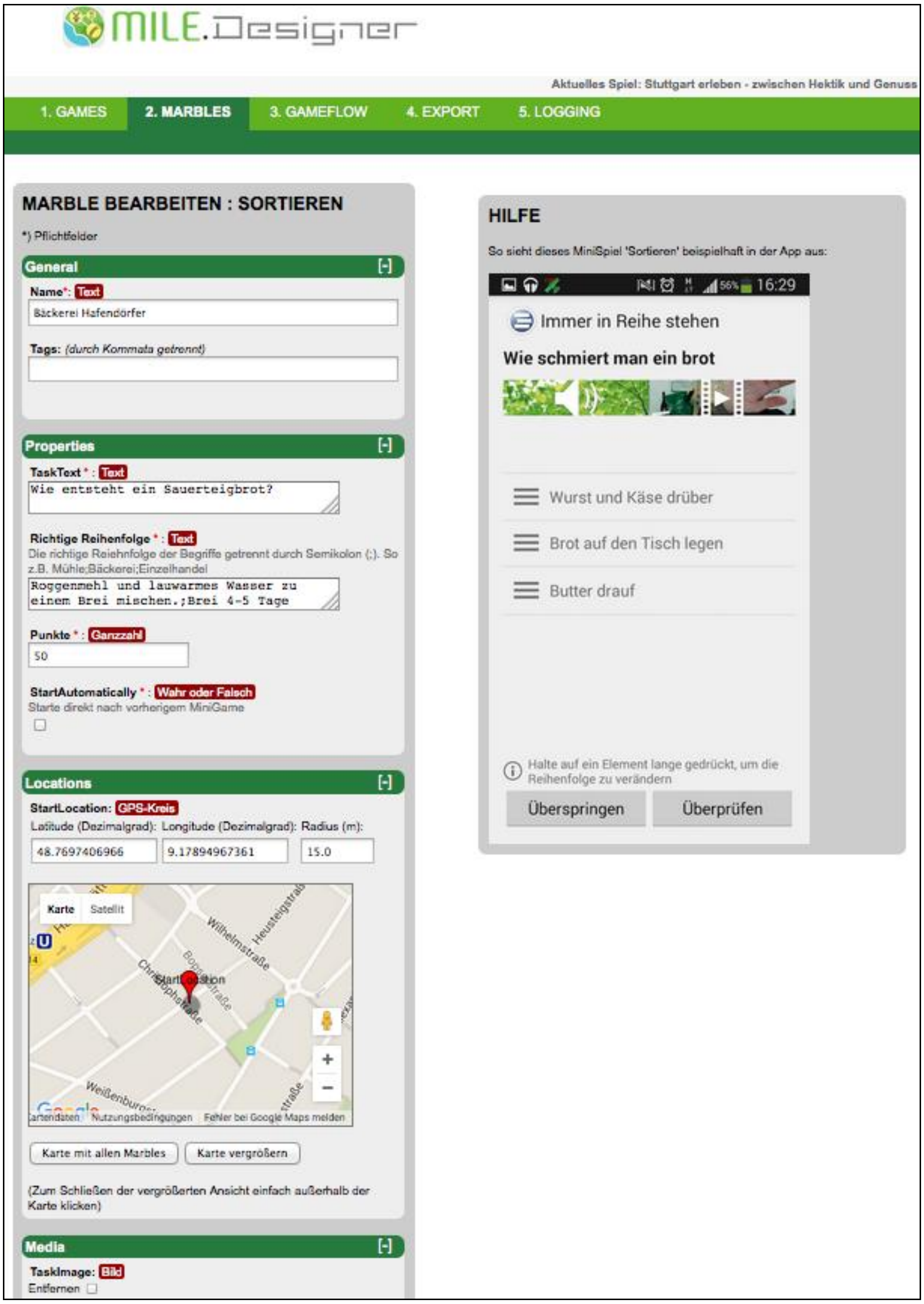

Figure 1. Template of a location-based task. The green tabs represent the workflow of the game design

The adapted game design model worked well and appearing problems – no matter if educational or technological – were identified together with the focus/workshop groups and solved successfully in the transdisciplinary team. The collaborative design process profited especially from the comprehensible and iterative formulation of the requirements review as well as its consequent application. Primarily the requirements of a simple MILE tools' usability and low technological barriers for inexperienced users were met within the design process.

Grounded on the design based research approach the findings are specific for the design process of the MILE tools, they have to be interpreted carefully and their transferability might be limited (cf. Anderson & Shattuck, 2012). But describing the general design process might notably help educators in other domains to set up location-based games efficiently and supports them in endeavors appearing during the design process (Dede, Ketelhut, Whitehouse, Breit & McCloskey, 2009).

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