Mobile gaming patterns and their impact on learning outcomes: A literature review

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Abstract. Mobile learning games have increasingly been topic of educational research with the intention to utilize their manifold and ubiquitous capabilities for learning and teaching. This paper presents a review of current research activities in the field. It particularly focuses is on the educational values serious mobile games provide. The study results substantiate their generally assumed motivational potential. Also, they indicate that mobile learning games may have the potential to bring about cognitive learning outcomes.

Keywords: mobile games, mobile learning, serious games, game design patterns, learning outcomes

1 Introduction

The interest in learning games has considerably grown within the last decade. This is not only due to the growing number of people playing these games. Games seem to enable students to gain skills needed in an information-based culture and to learn innovatively [16]. Investigations into educational games centre on the motivational potential and their low-threshold learning opportunities [5][10]. Games on mobile devices open up new target groups and new access to learning [26][19]. The Mobile Learning NETwork's (MoLeNET) review on learning game technologies suggests that mobile learning games provide potential for learning and teaching in terms of 'assessment', 'learner performance and skills development' or 'social and emotional well-being' [11]. In order to determine the mechanisms and design elements that make the use of novel learning scenarios successful and transferrable, it is necessary to explore how these technologies can be used for teaching and learning [12][15][17].

Therefore, the objective of this paper is to scrutinize the learning effects of mobile games and to understand the game mechanisms that have led to it. The results could provide valuable insight into the working mechnisms of mobile learning games that may positively influence future design decisions.

2 Theoretical Framework

The conceptual framework for our analysis comprises two main components: the game design patterns for mobile games by Davidsson et al. [8] and the taxonomy of learning outcomes by Bloom [4].

We decided to base our study on patterns because especially in the context of educational games, the traditional categorization of games according to genres has proved to be of little use [8]. As an expansion to the already existing set of Game Design Patterns by Björk and Holopainen [3], [8] introduced 74 new patterns that describe the unique characteristics of mobile games. Each pattern is identified by a core definition, a general definition, example(s), descriptions of how to use it (by listing related patterns or patterns that can be linked to it), the description of its consequences, relations with regard to instantiation (patterns causing each other's presence) and modulation (patterns influencing each other), as well as references. The pattern *Physical Navigation* for example "forces players of a mobile game to move or turn around in the physical world in order to successfully play the game" [8, p.18]. The MLG 'Frequentie 1550' makes use of this pattern. Players have to move around to find sources of information and to complete tasks [1].

Alternatively, learning games, as any educational measure, can be classified according to learning outcomes. Well advanced in years but notwithstanding adequate is Bloom's taxonomy [4] which sorts learning outcomes into the *affective, cognitive* and *psychomotor domain*. The affective domain encompasses attitudes and motivation. The cognitive domain deals with the recall or recognition of knowledge and the development of intellectual abilities and skills. For this domain, Bloom distinguishes six successive levels: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. The psychomotor domain encompasses manual or physical skills or the performance of actions. Learning outcomes in relation to this domain, e.g. exergames [29] we did not consider, as they have a different didactic approach.

3 Basis for the Review

For the review, we focused on 42 empirical research articles and practical papers. The following keywords were used: mobile educational game, mobile serious game, mobile learning game, mobile game-based learning, (location-based, ubiquitous, mixed reality, augmented reality, pervasive) learning game. We included practical papers (publicly available journal paper and conference proceedings) that (a) report evaluation results from pilot studies with mobile learning games, (b) have a clear focus on affective and/or cognitive learning outcomes, (c) allow identification of mobile game design patterns and (d) report on concrete learning outcomes where the learning outcomes can be correlated with a pattern used in the game.

Due to the educational focus of our analysis, we excluded 5 papers because they reported on games other than serious games, e.g. [14]. Also, we excluded 12 technical reports that focused on innovation, functionality, playability and/or usability testing,

e.g. [2][9][23][22] or [30]. For our purpose, an explanation of effects in relation to individual game play mechanisms was crucial. We excluded another 9 papers that provided evaluation data on a very general level, thus no pattern – effect correlation was possible. We did not take into consideration a specific age group. The research we reviewed was conducted mainly on pupils and young adults (age range: 10 – 25 years). Possible variations in effect due to that range of age were not considered.

4 Results

In the following, we present the most significant results of the survey. First, we scrutinized what games impact motivation (affective learning outcomes) and/or knowledge (cognitive learning outcomes). We then focussed on individual patterns used in the game and analysed how they impact affective and/or cognitive learning outcomes.

Table 1. Learning outcomes of mobile game patterns

Pattern Definition	Learning Outcome	Domain
Augmented Reality (AR) Players' perception of the game world is created by augmenting their perception of the real world.	Students feel "personally embodied" in the game. Their actions in the game are intrinsically motivated [24]. Learners are attentive [27].	Affective
	Students can discuss geometrical aspects [27]. They can describe and illustrate a disease model [24] and reflect on the process of learning [7].	Cognitive - Comprehension
Collaborative Actions Several players meeting at a location or attacking a target simultaneously.	Students are engaged in the game [7][12][20][24]. They exchange and discuss game progress [18].	Affective
	Participants are driven by a good team spirit [7].	
Cooperation Players have to work together to progress.	Students memorize their knowledge [28]. Students can explain and rewrite the knowledge learned [20].	Cognitive - Knowledge
Pervasive Games Play sessions coexists with other activities, either temporally or spatially.	Participants are exceptionally activated. Their attitude towards learning material improves [21].	Affective
	Students are able to transfer the learned material [21]. They reflect on their learning [6].	Cognitive - Comprehension
	Students can solve problems related to the object of learning. They can create new problems related to the object of learning [6].	Cognitive - Synthesis
	Students can judge and evaluate the material for a given purpose - critical thinking skills [6].	Cognitive - Evaluation
	Students are able to analyse and classify the learned material [6].	Cognitive - Analysis
Physical Navigation Players have to move around in the physical world to play the game.	Students are highly motivated [12].	Affective
	Participants are interested and moved [25].	
	Students's are exited [13].	

Roleplaying Players have characters with at least somewhat fleshed out personalities. Play is about deciding on how characters would take actions in staged imaginary situations.	Learners are involved in the game [13]. They feel highly engaged and identify with their roles in the game [7]. They are tightly associated with their tasks in the game [24][27]. They take an identity and want to work together [12].	Affective
	Students can give examples for the importance of communication and collaboration [24].	Cognitive - Comprehension

Our analysis reveals that game mechnisms such as *Collaborative Actions, Augmented Reality* and *Roleplaying* are vital motivational factors providing an incentive to get engaged with a learning environment and/or a certain topic.

The 'Virus Game' [24] e.g. integrated the pattern *Collaborative Actions* by providing different roles with distinct abilities. 'Each of the roles is dependent on the others for information and action. This fosters collaboration through jig sawing' [24, p. 40]. The study indicates that *Collaborative Actions* can bring about a change in students' attitude by providing insight into the working mechanisms of interpersonal communication. In the course of the 'Virus Game', students depend on each other for information and action. The 'jig sawing of complementary information' (p. 35) brought about 'an understanding of the interdependence of the roles' (p. 43). Students 'grasped the resulting importance of communication and collaboration for success' (p. 40).

Through the integration of *Roleplaying* in the game, students become more involved. Students felt personally embodied in the game and became tightly associated with the tasks they were responsible for 'like a real occupation' [24, p.40]. In the 'Virus Game', players take on the roles of doctors, medical technicians, and public health experts to contain a disease outbreak. The personal embodiment enabled by these roles motivated students' actions in the game [24].

Though empirical evidence on cognitive learning outcomes is inconsistent, some evaluations report on positive interrelations between mobile learning games and cognitive learning outcomes. Liu and Chu [20] investigate the potential of the context-aware, ubiquitous learning game HELLO (Handheld English Language Learning Organization). To measure possible cognitive effects, they evaluate students' English listening and speaking skills. Playing HELLO improves students' learning outcomes as they collaborated in real conditions (pattern: *Collaborative Actions*). The collaborative learning activity was a story relay race. In the beginning, the students could listen to several sample stories and then were asked to edit a story collaboratively [20].

5 Discussion and Future Work

This paper reports the results of a practical research paper review focussing on affective and cognitive learning outcomes mobile learning games may have. The review identified patterns within mobile learning games that positively influence motivation and knowledge gain. With regard to 'hard learning' [25], empirical

evidence is fragmented though, e.g. the diverse studies had different statistical bases (dependent/independent variables) and different research methods applied. The studies did not explicitly focus on the effects of isolated patterns but on a set of diverse patterns embedded in the games. Therefore, the impact of one particular pattern on learning is difficult to determine. Further research on the correlations between patterns and learning outcomes has thus to focus on a limited number of the patterns in existence [3][8].

To comprehensively support future design decisions, a comprehensive investigation of the effects of individual patterns has yet to follow. It will seek to understand which pattern impacts motivation and which knowledge. Future study settings have to comprise (a) an experimental variation of patterns, i.e. game settings that enable/disable individual patterns and (b) an in-depth variation of patterns, i.e. game settings that allow different instances for the same pattern. This way, measurable and feasible results can be obtained that may serve as a base for design guidelines which define (a) patterns which support the achievement of a desired learning outcome and (b) ways of how to apply the different patterns.

6 References

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