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Group-based mobile learning: Do group size and sharing mobile devices matter?

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ABSTRACT

Within the field of Game-based Learning (GBL) location-based games are based on pervasive and mobile learning to allow the creation of in situ learning activities considering gamification mechanisms. In these learning activities collaboration often plays an important role. Usually, groups of students have to perform different tasks with single mobile device. This paper studies the effects of sharing a mobile device within groups and the size of groups in students' engagement and their activity performance in an indoor location-based learning activity. In particular, the paper focuses on a game designed by a secondary education teacher to support a learning activity in a contemporary art museum. The teacher's design has been implemented using "QuesTInSitu: The Game" technology. A total of 76 students played the game during a 3-h activity in the museum. The analysis of the data shows that while there are not important differences in the satisfaction with the activity of the students carrying and not carrying the mobile device within their groups, carrying the device does have a significant (positive) impact in their performance. Group size (4 vs. 5 members) does not seem to be a variable affecting individuals' performance but students in 4-member groups express higher levels of engagement.

1. Introduction

Mobile learning has become a research field of interest of practitioners in all phases of education to facilitate informal learning in formal contexts (Pachler, Bachmair, & Cook, 2010). Key aspects of such interests are the growing significance of mobile devices in learners' everyday lives (Vinu, Sherimon, & Krishnan, 2011), and the increasing portability of these technologies, as well as the reduction in their cost and services. Besides, the use of mobile technology in education facilitates contextualized learning (Avouris & Yiannoutsou, 2012), leading to a new educational paradigm in which students can learn anytime and anywhere (Jones & Jo, 2004; Vinu et al., 2011). Considering the research domain of Game-based Learning, mobile learning brings the possibility of creating location-based games (Davis, 2002; Jeng, Wu, Huang, Tan, & Yang, 2010).

Educational location-based games rely on technological resources described as pervasive and ubiquitous computing, bringing possibilities to: enrich learning experiences by extending the learning beyond traditional classrooms and interacting with physical items by adding virtual layers of information; create fruitful learning experiences that involve exploration and cooperation (Hwang, Tsai, & Yang, 2008); access to contextualized information, communication, analysis and interrelation of real place (Roschelle, 2003); entertain and stimulate (Cabrera et al., 2005; Davis, 2002); and be effective in terms of increasing the motivation to learn and to acquire a deeper understanding of concepts (Yatani, Onuma, Sugimoto, & Kusunoki, 2004).

Within the literature we can find several examples on the use of location-based games for learning purposes. Alien Contact! (Dunleavy, Dede, & Mitchell, 2009) is intended to teach math, language arts, and scientific literacy skills. The mobile city game called Frequency 1550 (Huizenga, Admiraal, Akkerman, & ten Dam, 2009) helps students playfully acquire historical knowledge of medieval Amsterdam. Blåtannkoden (Ceipidor, Medaglia, Perrone, De Marsico, & Di Romano, 2009) involves solving different riddles related to the topics of a museum of telecommunications. Kurio (Wakkary et al., 2009) aims to engage family members to find historical information while visiting a museum. In Mad City Mystery (Squire & Jan, 2007) middle school students investigate an untimely death caused by murder, suicide or the combination of several interacting toxic chemicals that are commonly found in the region. UbiCicero (Ghiani, Paterno, Santoro, & Spano, 2007) proposes activities, such as quizzes, association games, memory games related to artworks of a museum. In Reliving the Revolution

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(Schrier, 2006) players try to find out who fired the first shot at the Battle of Lexington aiming to teach historical thinking and inquiry skill. Mystery in the Museum (Cabrera et al., 2005) provides a set of puzzle activities for a museum with cultural and historical educational content. In the game Savannah (Facer et al., 2004), children interact outdoors with a virtual Savannah and explore the opportunities and risks of being lions. Musex (Yatani et al., 2004) to solve different questions related to the science museum's exhibits by pairs of students. In Environmental Detectives (Klopfer, Squire, & Jenkins, 2002), students investigate a simulated chemical spill on a college campus.

All these previous examples show a diverse variety of location-based games for outdoors and indoors. As we can see, these games can address different learning purposes (e.g.: science, math, or history) and be implemented for diverse types of handheld devices (e.g.: PDAs, tangible computing devices, or mobile phones). Besides, these games are mainly characterised by students cooperating or playing collaboratively while sharing the same mobile device. In particular, group-internal collaboration (i.e. several participants working as a group and collaborating by using a handheld device) is the most common approach implemented in these educational contexts. However, still further research is needed on evaluating the impact of mobile technologies in group-based activities in which collaboration often plays an important role (Hsu & Ching, 2013). Besides, one of the key aspects that deserve further research is group size (Strijbos, Martens, & Jochems, 2004). In particular, group size can have an effect on both students' influence on other members of the group and on students' performance (Cress, Kimmerle, & Hesse, 2009; Schwabe, Göth, & Frohberg, 2005).

This paper aims to bring more insights on the effects of using shared devices by students to play location-based learning games. In particular, the paper describes a location-based learning game in which students have to play in groups and share a mobile device while visiting a contemporary museum. The aim of this paper is twofold: first, to evaluate whether there is a difference between carrying vs. not carrying the mobile device to interact with the application within their groups. And secondly, an analysis focused on whether the group formation (in terms of number of students per group) also has an impact on students' engagement and on their activity performance.

Therefore, the remainder of this paper is structured as follows. Section 2 describes the design and implementation of the location-based learning game. Then, the methodology followed to evaluate the two focus of interest is presented in Section 3. The results of such evaluation are reported in Section 4. Next, Section 5 discusses the obtained results. And finally, Section 6 presents the main conclusions including future research directions, as well.

Table 1
Summary of the teacher design.

Design elements	MNAC case
Number levels	3 Levels (one per museum's room)
Number questions	15 Questions
Scores for correct answers	60 Scores more
Scores for incorrect answers	20 Scores less
Number of hints	14 Hints
Scores hints	10 Scores less
Extra bonus	50 Scores more
Hints content	Short text about the context related to the question
Levels information	Short sentence about the museum's room
Feedback messages	Informal

2. Design of mobile application

A secondary school art teacher designed a location-based learning game to be played in a contemporary art museum (see Table 1).

The teacher used a metaphor based on "puzzle board games" (Melero, Hernández-Leo, & Blat, 2014) in order to design the mobile application. In particular, the resulted design consists of 3 levels (one level per museum's room) containing a total of 15 located questions. Some of the questions include hints, containing additional textual information, to help students find correct answers (see Table 2). Besides, the teacher also specified positive and negative amounts of scores associated to right and wrong answers. Finally, students are rewarded with extra bonus scores when all the questions for a particular level (i.e. room) are correctly answered.

The designed activity was deployed by the "QuesTInSitu: The Game", a mobile application compliant to a conceptual model proposed by (Melero & Hernández-Leo, 2014) based on computer-supported puzzle board games. "QuesTInSitu: The Game" interprets a game described according to the XML binding of the proposed conceptual model. In this particular case, the mobile application (see Fig. 1) works as follows. First, students using the application have to go to the specific located places where the questions are placed in order to solve them. Somehow similarly to jigsaw puzzles, each located question (associated to the museum's exhibits) can be solved as many times as necessary until reaching the correct solution. Positive and negative scores reflect the correct and wrong answers by the students, and hints can be accessed if the students need some kind of help to solve the questions. The game finishes when the students have answered all the questions.

Next section describes the methodology followed to evaluate the use of the implemented mobile application with secondary education students.

3. Methodology

Originally, 82 secondary education students (girls and boys between 14 and 16 years old) were expected to participate in the experiment. In order to set the students' groups, we asked the students to fill a form indicating the technical features of their Smartphones. After analyzing the answers, Smartphones of 20 students

Table 2
Example of the designed questions and hints.

Examples	Question content	Associated hint
Example 1	"Santa Maria d'Aneu": in this picture we can see two seraphim with wings. These contain eyes that symbolize that God sees everything. What are the seraphim doing?	Seraphim, according to Catholic theology, are spirits or angels of love, light and fire that surround the throne of God. According to The Bible, the prophet Isaiah saw seraphim in a vision. Seraphim also represent purity and, in the celestial hierarchy, they take up the supreme position
Example	Altarpiece of Santa Barbara: what do the distinctive attributes of Santa Barbara symbolize in this altarpiece?	Barbara was the daughter of Dioscor. Dioscor want to preserve her from the world and he lock her up in a tower. Barbara refused marriage proposed by his father. Then, Barbara was tortured and beheaded by her own father. As punishment, lightning killed him