Introducing mobility in serious games: enhancing situated and collaborative Learning

Sébastien George, Audrey Serna

Preprint version of paper:
Sébastien George, Audrey Serna, Introducing Mobility in Serious Games: Enhancing Situated and Collaborative Learning, in J.A. Jacko (Ed.): Human-Computer Interaction, Part IV, HCII 2011, p.12-20

Introducing Mobility in Serious Games: Enhancing Situated and Collaborative Learning

Sébastien George and Audrey Serna

Université de Lyon, INSA-Lyon, LIESP Laboratory, F-69621, Villeurbanne, France
{Sebastien.George,Audrey.Serna}@insa-lyon.fr

Abstract. This paper explores the introduction of mobile technologies in a particular serious games subset called learning games. We focus on two main purposes where mobility turns out to be useful: situated learning and collaborative learning. The article outlines the opportunities and the remaining challenges for these learning situations. Some important issues are highlighted for immerging learners in real context. We also propose some scenarios to illustrate the benefits of mobile devices in classroom situations.

Keywords: Mobility, learning games, situated learning, collaborative learning, outdoor mobile learning, in-class mobile learning.

1 Introduction

Mobile devices are increasingly present in our professional and personal lives. Their growing capabilities (memory, CPU), their connectivity (3G, wireless technologies) and their features (web browser, GPS, camera and video recording. etc.) open new opportunities, particularly in the field of education. Mobile learning brings new technological and educational challenges as evidenced by the many issues raised during recent conferences on this topic. For instance, mobile technologies enable more motivating learning experiences.

In this paper, the potential of the use of mobile technologies in serious games is explored. Serious games are "*games used for purposes other than mere entertainment*" [1]. We focus specifically on learning games, a serious game category aiming at using game mechanisms to promote the learning of knowledge and the building of skills.

Mobility and mobile technologies could be of a great interest in learning games situations for two main purposes:

- to favor situated learning,
- to promote interaction and collaboration between learners learners for in-class situations.

2 Mobility Technologies to Favor Situated Learning with Games

Mobile learning, or M-learning, allows learners to access learning material anytime and anywhere through several devices. From our point of view, a M-learning application must be able to extract, interpret and use contextual information and adapt functionalities to the current context of use. In this way, the learning could take place in situation. We refer to situated learning theory [2]. In this theory, learning act is situated in the activity in which it takes place. Situated learning occurs when learners work on authentic tasks that take place in real world. Using learning games based on role-playing in a real situation could favor the learning of particular behaviors. Learning may occur in location and time which are significant and relevant for learners.

Several innovative educational situations can be identified. We illustrate them in the following parts of this section.

2.1 Taking the Natural Environment into Consideration

A possibility with mobile learning is to use the natural environment as a source of information. Some knowledge needs students learning through observation and is not very easy to teach by either traditional classroom teaching or web-based learning environment. Mobile application proves to be useful in this case. For example, the "Butterfly-Watching System" [3] supports an activity in which each learner takes a butterfly picture with a PDA (Fig. 1). Retrieval technique is applied on a database to search for the most closely matching butterfly information and is returned in real time to the learner's device.

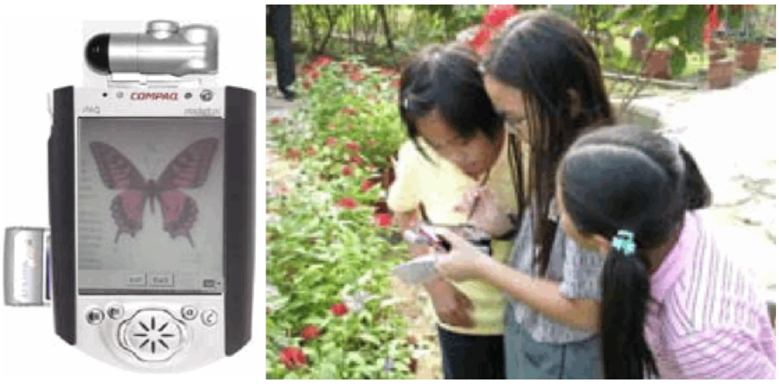

Fig. 1. The Butterfly-Watching System [1]

With a similar idea based on observation, an augmented reality game was designed to teach zoo visitors about the illegal wildlife trade [4]. So natural science learning could benefit from outdoor mobile learning game technologies by allowing open activities as scavenger hunt or identification in a natural environment.

2.2 Engaging Learners into Simulation as Part of a Dynamic System

Mobile learning offers the opportunity to extend the notion of microworld [5]. In a microworld, learners can explore alternatives, test hypotheses, and discover facts about that world. With mobile technologies, the learners themselves can act in an immersive simulation of a dynamic system. For instance, in Virus Game [6], learners took part in a participatory simulation about the spread of a virus. Students wear an active badge and the proximity with another student may spread the virus. Learners can define strategies to understand how the virus is spreading, who is the initial infected person, who is immune… The result is that students were really engaged with the simulation, and found it to be a rewarding and stimulating experience.

Another example of learning game engaging the students into a simulation is Savannah [7]. In this game, children use PDAs, moving around a playing field outdoors and acting as lions. The main challenge is to understand and survive in a territory. They have to collaborate in order to achieve the games objectives.

The goal of these kinds of research works is to move a simulation into the real world, so students can interact with and see the effects immediately. By making them actors of the simulation, they are more engaged in the learning process. Naismith *et al.* [8] highlight the benefit of having a learner, through a networked device, become part of a dynamic system: “they do not just watch the simulation, they are the simulation”.

2.3 Favoring the Learning of Professional Skills and Gestures

Combining the real and the virtual can be a good solution to achieve educational goals. Augmented reality techniques could be used to teach some gestures. For instance, HMTD (Help Me To Do) [9] uses wearable computer and head-mounted display to teach maintenance and repairing of professional appliances. The main idea is to put the user in a precise situation (use, maintenance, diagnostic or repairing) to to understand functioning principles and commands. The augmented reality allows to link different representation of the same information.

The Context-Aware Agent-Supported Augmented Reality System (CAARS) [10] is an industry research initiative developed for the manufacturing training domain. This

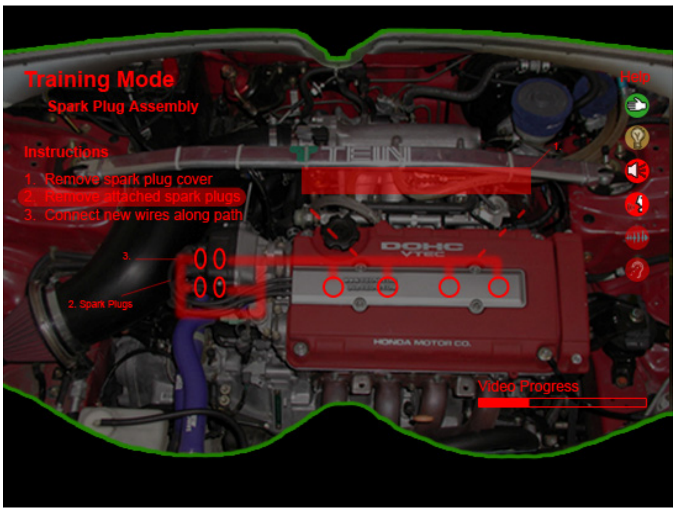

Fig. 2. CAARS user’s view of an engine with see-through goggles [10]

system has been extended for developing a mobile augmented reality learning game with a virtual instructor in mixed reality. The goal is to favor the learning of professional skills as well as psychomotor task in real world environments.

This kind of mobile augmented reality learning game is at the beginning. Learning scenarios are quite basic at the moment. We think that next generation will integrate more elaborate and collaborative games scenarios that will increase the learners' motivation.

2.4 Mobile Learning Game for Situated Learning: Main Issues

Mobile learning game still in its infancy and a lot of research works should be done for a deeper understanding of its design principle and learning impacts. We can highlight several issues:

- **Supporting temporal mobility:** Dispersion in time makes it hard to define precisely the start and end of a mobile learning session. Learning scenario should consider this aspect and support not only the spatial mobility of students, but also their temporal mobility (for example by giving the opportunity to easily stop and resume a session). Facilities should also be provided to facilitate asynchronous discussions in a contextual way [11].
- **Integrating mobile applications into global learning systems:** The question of the integration of a mobile learning game application can be addressed from two points of view. First, a learner should be able to switch seemlessly between a desktop application and a mobile application. This HCI concept can be done with solutions of user interfaces redistribution [12]. Secondly, information gathered during mobile use could be reuse on desktop applications in order to adapt the learning game to each learner experience. So, mobile learning applications should be seen as a part of a whole, in relation to other learning tools used by students.
- **Making a room for the teacher:** we know that human teachers play an important role in e-learning, even if virtual tutors are used. Teachers favor the transfer of knowledge from one situation to another, from one context to another. So the role of teacher should be deeper integrated in mobile learning game scenarios. In particular, tutoring should be facilitated by giving teachers specific tools to finely monitor students' activities.

To sum up, in situated learning research, mobility is considered as a key issue for immerging learners in real context. From this perspective, most of mobile learning games are designed for "outside the classroom" scenarios. However, introducing mobility in a well-known and static environment, such as the classroom, can also present some advantages.

3 Introducing Mobile Devices into the Classroom to Promote Learners Interaction

The introduction of mobile technologies into the classroom can present some advantages in terms of collaborative learning. This theory is based on the role of social interactions in the process of learning. Mobile devices present two advantages that seem to favor social interactions and collaborative situations. First, they can easily communicate with other devices. Secondly, collaboration between learners is possible through and around the device [8].

3.1 Existing Systems Using Mobility in the Classroom

Concretely, a major part of the studies focusing on the introduction of mobile devices into classrooms are limited to systems that gather responses and provide feedback during in-class exercises. Several studies use mobile phones for submitting solutions in the form of text or photos via SMS/MMS services during exercises or revisions [13], [14]. Experimenting these systems underline usage limitations due to the device features. Learners regret, for instance, a lack of detailed feedback due to the limited size of the screen, and they express a desire to use other platforms to access to more functions. They suggest, for example, to use laptops or tablets to have a best vision of their work or to consult resources such as Wikipedia. To overcome partially these problems, others studies prefer the use of tablet-PC to allow learners to submit digital ink answers [15]. However, all these studies are based on a behaviorist learning approach: they focus on learners' personal work and are applied to classic exercises, neither game motives nor collaboration interactions are used.

In the end, to come closer to the usage of mobile technologies that we expect into the classroom, research on mobile-CSCL (computer-supported collaborative learning) presents some interesting leads. MCSCL explore the use of handheld devices to support a natural mobile collaboration environment with face-to-face social interactions [16]. In particular, two studies catch our attention. The first one introduces handheld devices in a collaborative learning (CL) activity for ordering numbers for children [16]. The authors use mobility to overcome usability problems encountered in the classic CL activity. In particular, mobility allows enhancing children' participation and social interactions, including coordination, organization of individual work with joint group activities, involvement in the activity, negotiation, synchronization, etc. The second significant work, called Caretta, introduces mixed reality into the classroom to favor face-to-face collaboration [17]. A sensing board with RFID recognition insures collaboration in a shared space via physical objects and PDA devices support simulation activity in personal spaces. Mobility is here considered as a support for personal reflection within a CL activity.

3.2 Main Issues to Consider When Using Mobility in the Classroom

This brief overview of literature demonstrates that the introduction of mobile technology in the classroom is not fully exploited and points out some considerations to be taken into account when designing mobile learning games in the classroom:

- Whatever the approach chosen (behaviorist or collaborative learning), the use of mobile devices has to be combined with others devices. In the MCSCM approach, the combination of (homogeneous or heterogeneous) platforms allows personal work as well as synchronization/collaboration with the rest of the group. As counterexample, the exclusive use of mobile phones for in-class exercises revealed lack of significant detailed information and too restricted functionalities.

- Mobile technologies can strengthen the success of learning games. Schwabe & Göth [18] address some general issues in designing mobile learning games in regard to social aspects (such as face-to-face collaborations) and representation of interesting aspects of reality (with augmented reality for instance), leading to better focus and motivation from learners.
  Despite these advantages, the use of mobile devices inside the classroom is little explored in mobile serious games (except in the MCSCL approach).
- The studies presented here are considering mobility from the learners' perspective. Very few studies envisage teachers as end-users with mobile tutoring requirements. So far, tools developed for teachers using mobile technologies concentrate on management of administrative tasks [8].

3.3 Illustration of Mobility Benefits in the Classroom

From these considerations, different contexts of use emerge from the introduction of mobile device into a classroom. For example, learners could use a platforms composition (using a shared computer and their personal Smartphone), or they can play different roles (like in Savannah [7]). To be efficient, the interface of the learning activity (or educational scenario) must support and must be adapted to the different potential contexts of use. To go further, we propose to consider the introduction of mobile technologies on learning games relying on a HCI concept called plasticity. Plasticity denotes the capacity of user interfaces (UI) to adapt to the variation of context of use while preserving usability [19]. Depending on the situation, UI can be transformed (remolding) or can be redistributed among the available interaction resources (redistribution by partial or total migration [12]). More than adaptation itself, we'll use these mechanisms to explore the possible usage of mobile devices into learning games (see [20] for similar approach for e-government).

In a classic learning game session held on our industrial engineering school department, students are working by groups. They usually follow the educational scenario on a same computer and collaborative tasks are done with pen and paper. During a session, the time is shared between group work and debriefing with the tutor. For example, in the game named "Puissance 7" (P7), students have to solve an industrial problem by choosing well-known quality tools. In this particular context, we identify several situations where the use of mobile devices combined with plasticity mechanisms can enhance collaborative learning.

Moment 1
John, Helena and Peter are taking part of P7. In the educational scenario, they have to lead an investigation to find out the causes of a problem in a particular company and choose solutions (learning problem solving quality methodology and tools) on a shared computer. At each stage of the game, they have to choose the appropriate tool from the quality methodology. They can vote and justify their choices on their Smartphone. Peter doesn't choose the same tool as John and Helena. After discussion, he let be persuaded and they validate their final choice on the shared computer so that they can reach the next stage of the game.

Analysis

Thanks to a distribution of the HCI on both personal Smartphone's and shared computer, learners can take their own decisions and share or synchronize them with the rest of the group. Therefore, the platforms composition guarantees the regulation of social interactions offering decision making and negotiation spaces. In addition, as in Zurita *et al.* [16] study, the introduction of mobile devices assures that each member of the group participated.

Moment 2
As they advanced in the investigation, John, Helena and Peter collect information by interrogating people in different departments of the simulated company. But Helena is a little confused with all the information collected. Whereas her friends are completing the elements that they found on the shared computer, she decides to look back to what they discovered. She uses her Smartphone to look at the company printed map as if she had a magnifying glass: thanks to the augmented system she can easily repair the departments already visited (additional information is added to the camera-based vision on the screen of the Smartphone). She comes closer to the technical department and the information collected is displayed. She can play again the interview with the technical manager, check the cues collected, etc. She can specify the importance of the information. By moving away her Smartphone, she comes back to the global augmented vision of the company map. The technical department is now marked as containing major information.

Analysis

The augmented system allows each learner to trace the investigation from a personal perspective (adding some personal assessment on collected information for instance). As suggested in Caretta [17], the use of Smartphones creates personal spaces that support individual activity without interfering with group activities (on the shared computer). In addition, the use of augmented reality should enhance the immersion of learners into the game leading them to get more involved in the investigation (as in [18]).

Moment 3
At the end of a game level (or stage), John, Helena and Peter meet again Patrick, the SG tutor, and the rest of the class at the central table for a debriefing session. John put his Smartphone on the central table. Doing so, the HCI offers him a global vision of the problem solving methodology and the course of his own team. As Patrick is explaining some theoretical concepts manipulated during the previous stage, John can inspect on his Smartphone all the tools used previously and the consequences on their investigation and on the decisions they made.

Analysis

During collective sessions (moment 1 and moment 2), tools provided on mobile devices allow learners to work individually within collaborative activities and they are combined to the shared platform for coordination/synchronization. In these sessions, learners are playing the role of quality consultants and are part of team. When they come to the central table for debriefing sessions, they occupy the role of student reflecting on the methodology learned, tools choices, consequences of a decision, etc. (the concept of multirole support is explored in Savannah [7]). Regarding HCI plasticity, the change of role triggers an adaptation the Smartphone HCI that will provide appropriated tools.

Moment 4
Patrick is the tutor of P7. During collaborative sessions, Patrick has to help the different groups in their investigation giving them some clues. Thanks to his tablet, he can visualize additional information regarding the investigation (such as recognized key-words in the interviews phases). In addition, his tablet provides him an overview of groups' progress in order to help him to synchronize the different groups when needed. When he gets closer to a particular group, Patrick can migrate the detailed view of the group progress on his phone. He can also trigger the synchronization by using his tablet as a remote control (the game level will be automatically completed).

Analysis

Here the mobile device is considered from the tutor or teacher perspective. The functionalities and information provided by the system are adapted according to the position of the tutor within the classroom (his proximity to a particular group for instance).

Future work will be focused on the implementation of presented scenarios for collaborative learning enhancement and validation with users' experimentation.

4 Conclusion

In this paper, we present how the use of mobile technologies in learning games can favor situated learning and collaborative learning. We outlined the opportunities and the remaining challenges for each of these learning situations. We have also identified common issues which are important to address for the future of mobile game-based learning. A first aspect concerns authoring tools. The design and development of mobile learning games is complex and time consuming. Methods and tools currently exist to help the design of learning games [21]. New functionalities should be added to give authors the possibility of exploring pedagogical innovations with mobile devices. A second issue is related to the place of the teacher in mobile learning game situations. For both classroom and outdoor contexts, learning impacts greatly depends on the quality of human tutoring. The design of a specific and adapted instrumentation is essential in order to support this tutoring activity in a mobile learning environment.

References

1. Susi, T., Johannesson, M., Backlund, P.: Serious games – An overview. School of Humanities and Informatics. University of Skövde, Sweden (2007)
2. Lave, J., Wenger, E.: Situated Learning. Legitimate Peripheral Participation. Cambridge University Press, Cambridge (1991)
3. Chen, Y., Kao, T., Yu, G., Sheu, J.: A mobile butterfly-watching learning system for supporting independent learning. In: Proceedings of the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education, JungLi, Taiwan, pp. 11–18 (2004)
4. Perry, J., Klopfer, E., Norton, M., Sutch, D., Sandford, R., Facer, K.: AR gone wild: two approaches to using augmented reality learning games in Zoos. In: George, S., Serna, A. (eds.) Proceedings of the 8th International Conference on International Conference for the

Learning Sciences, vol. 3, pp. 322–329. International Society of the Learning Sciences, Utrecht (2008)
5. Papert, S.: Mindstorms, Children. Computers and Powerful Ideas. Inc., New York (1980).
6. Colella, V.: Participatory Simulations: Building Collaborative Understanding Through Immersive Dynamic Modeling. Journal of the Learning Sciences 9, 471 (2000)
7. Facer, K., Joiner, R., Stanton, D., Reid, J., Hull, R., Kirk, D.: Savannah: mobile gaming and learning. Journal of Computer Assisted Learning 20, 399–409 (2004)
8. Naismith, L., Lonsdale, P., Vavoula, G., Sharples, M.: Literature review in mobile technologies and learning. University of Birmingham (2004)
9. David, B., Chalon, R., Champalle, O., Masserey, G., Yin, C.: Contextual Mobile Learning: A Step Further to Mastering Professional Appliances. IEEE Multidisciplinary Engineering Education Magazine 2, 5–9 (2007)
10. Doswell, J., Harmeyer, K.: Extending the 'serious game'boundary: Virtual instructors in mobile mixed reality learning games. In: Digital Games Research Association International Conference (DiGRA 2007), Tokyo, Japan, pp. 524–529 (2007)
11. George, S., Lekira, A.: MeCoCo: A Context-Aware System for Mediated Communications. International Journal of Interactive Mobile Technologies (iJIM) 3, 26–33 (2009)
12. Balme, L., Demeure, A., Barralon, N., Calvary, G.: CAMELEON-RT: A software architecture reference model for distributed, migratable, and plastic user interfaces. In: Markopoulos, P., Eggen, B., Aarts, E., Crowley, J.L. (eds.) EUSAI 2004. LNCS, vol. 3295, pp. 291–302. Springer, Heidelberg (2004)
13. Lindquist, D., Denning, T., Kelly, M., Malani, R., Griswold, W.G., Simon, B.: Exploring the potential of mobile phones for active learning in the classroom. ACM SIGCSE Bulletin, 384–388 (2007)
14. Thornton, P., Houser, C.: Using Mobile Phones in Education. In: Proceedings of the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2004), pp. 3–10. IEEE Computer Society, Los Alamitos (2004)
15. Koile, K., Singer, D.: Improving learning in CS1 via tablet-PC-based in-class assessment. In: Proceedings of the Second International Workshop on Computing Education Research, pp. 119–126. ACM, New York (2006)
16. Zurita, G., Nussbaum, M., Shaples, M.: Encouraging Face-to-Face Collaborative Learning through the Use of Handheld Computers in the Classroom. In: Proceedings of the 5th International Symposium on Human Computer Interaction with Mobile Devices and Services, pp. 193–208. Springer, Udine (2003)
17. Sugimoto, M., Hosoi, K., Hiromichi, H.: Caretta: a system for supporting face-to-face collaboration by integrating personal and shared spaces. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 41–48. ACM, New York (2004)
18. Schwabe, G., Göth, C.: Mobile learning with a mobile game: design and motivational effects. Journal of Computer Assisted Learning 21, 204–216 (2005)
19. Thevenin, D., Coutaz, J.: Plasticity of user interfaces: Framework and research agenda. In: Proceedings of INTERACT 1999: IFIP TC. 13 International Conference on Human-Computer Interaction, Edinburgh, UK, pp. 110–117 (1999)
20. Calvary, G., Serna, A., Coutaz, J., Scapin, D., Pontico, F., Winckler, M.: Envisioning Advanced User Interfaces for E-Government Applications: A Case Study. In: Practical Studies in E-Government: Best Practices from Around the World, p. 205 (2010)
21. Marfisi-Schottman, I., George, S., Tarpin-Bernard, F.: Tools and Methods for Efficiently Designing Serious Games. In: Proceedings of the 4th Europeen Conference on Games Based Learning ECGBL 2010, Copenhagen, Denmark, pp. 226–234 (2010)