SUPPORTING TEACHERS TO DESIGN AND USE MOBILE COLLABORATIVE LEARNING GAMES

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ABSTRACT

Mobile Collaborative Learning Games combine all the ingredients necessary to attract students' attention and engage them in learning activities. However, designing a coherent scenario that combines mobility, game mechanics and collaborative learning is quite a challenge. In this article, we take the first step by proposing several game patterns that naturally integrate these mechanics in order to support educational goals. We also discuss ways to support teachers design these applications and adapt them to their course material and specific learning situations. Finally, we identify the technical challenges linked to the deployment of these applications such as connectivity between mobile devices, geolocation, real time adaptation of scenarios by teachers and the use of data collected on the field as course material.

KEYWORDS

Mobile Learning, Learning Games, Collaborative Learning, situated Learning, Game mechanics, adaptation

1. COLLABORATE, PLAY AND MOVE

Teachers often feel the need to try innovative learning mechanics in order to motivate the new generation of students. In this first section, we describe three promising mechanics and their positive effects on learning.

1.1 Mechanics to Enhance Learning

Collaboration is widely used by teachers as a means to enhance learning (Freinet, 1993). This is not surprising, given the fact that group work facilitates learning through *social interactions* and increases the students *personal engagement* in the learning process (Doise *et al.*, 1975) (Johnson *et al.*, 1998).

Lately, the concept of Learning Games has also become popular for teaching various types of skills. The main idea is to use **game** mechanics such as competition, rewards, or simply curiosity in order to captivate the learners' attention and push them to learn (Dondlinger, 2007). When used correctly, these game mechanics enhance the learners' experience with *emotion*, which has positive effects on engagement and memory (Damasio, 1995). These game mechanics also position the learner as the central *actor* and motor of his own learning experience. Even though learning games come in various shapes, such as simple card games or live role planning games, the latest ones tend to be designed as video games. This is not only because of the *attractive* and immersive nature of video games but also because computer applications can unload teachers from repetitive and time consuming activities so that they can concentrate on providing guidance and help to their students. Computer Learning Games can also provide automatic adaptation to the users profile and monitoring tools for teachers.

Finally, the use of **mobility** (with any kind of mobile device) for teaching has also increased now that a large amount of students own smartphones. For example, several systems offer pooling functionalities that teachers use during their lectures (Rubner, 2012). This allows them to get real-time *feedback* from each student and adapt their presentation accordingly. Mobility also opens the possibility of *situated learning* in various physical settings. For example, Ardito *et al.* (2012)and Loiseau *et al.* (2013) have designed mobile applications to teach students about the history of geological sites and cities while they are walking around them. This can also be very useful when teaching professional skills and gestures in real environments. For example, the *MARL* simulator (Jayfus and Kathleen, 2007) uses augmented reality to teach professional skills

and psychomotor tasks on real car engines. Finally, mobility can be useful to explain a concept with *live simulation*. The *Disease Simulation* (Colella, 2000), for instance, was designed to teach children how a virus spreads. The participants wear digital tags that indicate if they are sick or not and, the same way a real virus spreads, the virtual illness is propagated when the children get close to one another.

1.2 Combining Mechanics

While *collaboration*, *game* mechanics and *mobility* have proven to enhance learning on their own, we believe that their combination would be even more powerful because of the way they enhance and facilitate the use of each other. Even though a couple of researchers have successfully combined these mechanics, there is no study that identifies what makes this specific trio particularly powerful. In the next paragraph, we therefore identify and analyze the synergies between collaboration, game and mobility, represented as dotted arrows in Figure **1**. Note that, on the same figure, the positive impacts of collaboration, game and mobility on learning, described in the first section of this article, are represented by full arrows.
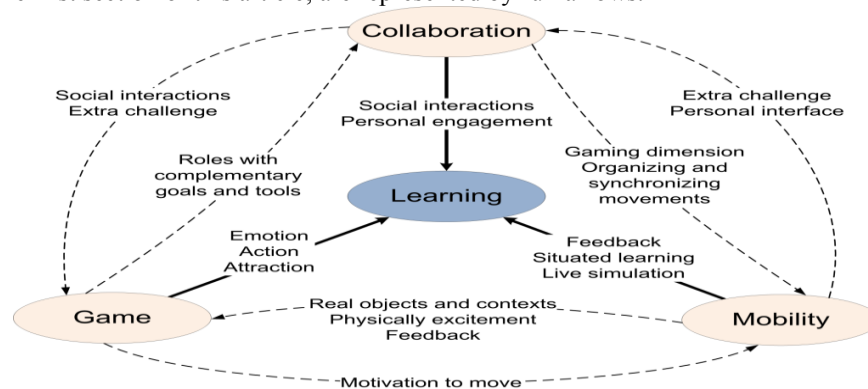

Figure 1. Positive interconnections between Collaboration, Game, Mobility and Learning

1.2.1 Collaboration and Game

Setting up collaborative learning activities, where all the members of a group participate equally, is very challenging. Gómez *et al.* (2013), argue that this is possible by designing the activities so that each of the students has a specific interdependent task he/she needs to achieve. In order to encourage the students to do their one tasks, they designed a game where three students each hold a mouse, connected to the same screen and, in order to win the game, the team needs to complete various tasks that can only be done with one specific mouse. In other words, the students are given different tools (in this case, a mouse), which allow them to complete complementary tasks, and therefore collaboratively achieve a common goal. We believe game mechanics provide a natural way of setting up such mechanics. Indeed, like in *Environmental Detective* (Klopfer and Squire, 2008)*,* the game can be designed so players are given *complementary roles* (e.g. manufacturing company worker, environmental activist) with specific *goals*, thus forcing each learner to speak for him/herself. The game can also push this principal further by giving specific *tools* and powers to these roles (e.g. sorcerer, troll, chemist) so that the students are the only ones capable of doing certain tasks.

   On the opposite, the use of collaboration is also recognized as one of the mechanisms that enhances games (Björk and Holopainen, 2004). This is due to the *social interactions* and the *extra challenge* of team decision making.

1.2.2 Game and Mobility

Mobility offers new possibilities for enriching games and enhancing the users experience by taking advantage of *real objects* (e.g. plants, buildings, animals) in *real contexts* (e.g. archeological or geological site, factory, nature) (Daniel *et al.*, 2009). Several studies have also shown that *physically excitement* caused by walking, running or jumping during the game increases players engagement (Bianchi-Berthouze, 2013). Finally, smartphone functionalities such as GPS, accelerometer and other sensors that collect *feedback* can provide valuable information in order to improve engagement in the game. For example, if the player has

been standing in the same area for a long time or has been going round in circles, the game could automatically provide some hint on what to do next.

On the opposite, game rewards such as extra points or unlocking the next part of the story, can also help *motivate the learners to physically move* to the next location. This is for example the case of *Rewild*[1], an adventure games that motivates non-hikers to discover the beauty of nature.

1.2.3 Mobility and Collaboration

If well designed, collaborative activities can greatly enhancement the concept of mobility. Indeed, by forcing the team members to *organize and synchronize their movements* in order to cover the whole map or to be at a specific location at a given time, collaboration can give a new *gaming dimension* to mobility.

On the opposite, mobility can lead to situations where the team members are physically dispersed and don't always have the means to communicate. These situations make collaborative activities much more *challenging*. In addition, when working in collaboration, it often happens that the team members don't progress at the same speed. For instance, some of them might need to come back on certain activities or read the instructions again. With the use of *personal mobile interfaces*, each student can navigate freely in the activities and submit their personal work when they feel ready (George and Serna, 2011).

As we have seen, several learning applications already take advantage of the synergies between *collaboration*, *game* mechanics and *mobility*. However, their design remains experimental; without any methods to make sure these mechanics are used to their full potential. In addition MCLG (Mobile Collaborative Learning Game) design is far from being trivial. Indeed, not only does it combine the challenges identified by researchers in Collaborative Learning, Learning Games and Mobile Learning such as designing coherent scenarios, reducing production cost and helping teachers and students adopt the applications but it also raises extra challenges resulting from the difficulty of combining these three mechanics. Given the power of this trio and the high demand for applications that motivate and engage students, we believe it is important to assist their design and use. In this article, we first put forward several solutions for designing coherent scenarios that integrate *collaboration, game* mechanics and *mobility* in such a way to create the desired synergy and facilitate the *learning* process. Then we discuss how to support teachers to use MCLGs and adapt them to their course material and their specific learning situations.

2. DESIGNING LEARNING SCENARIOS

As we have shown, MCLGs have all the necessary ingredients to engage students in learning activities. However, it takes more than just knowing the right ingredients to make a good cake. Indeed, the ingredients need to be carefully selected, dosed, mixed and cooked in a certain way in order to create the final enhanced product, that is much more than just an addition of all the ingredients. We believe designing MCLGs raises the same challenge: selecting, dosing and combining *learning* activities, *collaboration, game* mechanics and *mobility* in order to create synergies and hence, maximize educational value.

Because there are no recipes or authoring tools that provide guidance for designing MCLGs yet, we take the first step by proposing three game patterns that naturally integrate these mechanics and support specific educational goals. Bear in mind that this is just the first step, as we would also need to provide teachers with guidance and more examples in order to help them choose and use the right patterns.

2.1 Live Action Role-Playing Game

LARPs (Live Action Role-Playing games) are built around role playing activities guided by rules. Players usually have full control over decisions made by their character and the game scenario is completely dependent on their actions. LARPs are usually guided by a game master who facilitates the game flow, administrates the game rules and keeps score (Tychsen *et al.*, 2006). In terms of education, LARPs seem ideal for practicing social skills or understanding complex subjects that don't have a given solution and involving several actors. In addition, the role of the game master is perfect for teachers because it allows them to observe the learners and adapt the game scenario accordingly. A variation of this game type is to

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[1] http://www.rewild.fr

strip the roles down to the minimum and focus on the rules that condition the interactions between the players. This can be used to create a participatory simulation of a specific mechanism such as the virus epidemic in the game Disease Simulation, described in the first section of this article.

Similarly to game design pattern libraries (Björk and Holopainen, 2004), we depict each MCLG pattern with a specific structure and an example. These examples are inspired by real games, designed and used by teachers at different levels of education.

Example 1. Pattern LARP - Fast way construction

Educational goal: Understand the mechanisms of democracy and practice how to defend an opinion by collecting data and presenting it orally.

Game: The town mayor has the project of building a fast way thought a section of his city. However, he would like to debate this project with the citizens before making a decision.

Mobility: With a map of the construction plan for the road, the players need to investigate on the field to find elements that are in favor or against the construction of the road. Regularly, the players are summoned to a general town meeting to present and discuss their point of views on the road project.

Collaboration: At the beginning of the game, the players are assigned to complementary roles so that they represent the town population:
  - The mayor would like his town to grow but doesn't want to go against the general opinion
  - Citizens who live next to the construction area and would be bothered by the noise
  - Citizens who would be able to reduce their transportation time by taking the fast way
  - Local store managers who would increase their sales if the fast way was built
  - Environmental activists who want to protect the bird sanctuary, the road will go through
  - Owners of construction companies who would be able to hire people to work on the road
  - Two journalists, one in favor and one against the road construction, who need to conduct surveys on the general opinion and keep the population informed of the local news
Note that the scoring mechanism is different for each role and is designed so that the players will need to negotiate and come up with a solution that suits all the participants. However, the teacher that used this game noticed that, even though the scoring mechanism seems to motivate the students in the beginning, they often forget it completely by the end of the game.

2.2 Mystery Game

The scenario of a mystery game is built around a central mystery that players need to solve by collecting clues, analyzing them and deducting possible solutions. This model is very similar to the case-based teaching method that consists in presenting learners with a problem, inspired by a real situation, and putting them in the position of decision makers. We believe this game model is therefore perfectly adapted to make students practice the use of theoretical knowledge through collaborative resolution of complex cases. These cases can cover a very large variety of educational domains: finding what pathology a patient is suffering from, understanding what broke a piece of machinery, finding the best solution for a divorce case (Marfisi-Schottman *et al.*, 2013)...

Example 2. Pattern Mystery game - Company investigation

Educational goal: Practice how to use decision making tools on a real complex problem.

Game: The students are hired by a company to understand why it has been losing so much money lately. They have a limited time to identify the problem and find solutions.

Mobility: The players need to physically go to various rooms of a building in order to investigate. They collect information, such as videos of fictional employees being interviewed or important documents, by scanning the QR codes in each room. The teacher regularly gathers all the students to discuss their finding and reflect on the decision making tools they can use to help them.

Collaboration: In order to finish the game in time, the players, in groups of three, needs to organize and divide their tasks. For example, in the beginning of the scenario, each player decides which rooms he/she is going to visit in order to collect information and, in the next phase, when they have several hypotheses on what is causing the money los, they also need to divide the work for further investigations.

2.3 Treasure Hunt

A treasure hunt is a game in which players attempt to find hidden items with a series of clues. Because this type of game pushes players to explore the environment and get familiar with it, we think it is very well suited to teach about the characteristics of real items, locations and environments.

Example 3. Pattern Treasure hunt - Bacchus' party

Educational goal: Learn about life in Ancient Rome and the end of Pompeii.
Game: The players are hired by Bacchus to organize a party in his honor. They are given a list of items that they need to find (beverage, food, gests and animations) and a certain amount of gold coins. However, the amount of money is not sufficient, so the players will have to make a decision: only buy what they can, and therefore score very low on Bacchus' happiness scale, or steel! If they steel, the volcano will start showing signs or eruption and the virtual inhabitants of Pompeii will tell them that it is God who is angry at the sinful population. At the end of the game, whatever the decisions made by the players, the volcano erupts anyway, just like it really happened. If they stool, God starts the eruption and if they didn't steel or didn't collect all the items in time, and therefore didn't fulfill Bacchus' expectations, his fury triggers the eruption.
Mobility: The students have a few hours to physically go around the ruins of Pompeii and find the items they need in the real locations where the shops where. To find the gests and animations, they have the choice between the house of poets and dancers, the gladiator barracks and several villas of noble families.
Collaboration: In order to collect all the items in time, the players need to divide their tasks. When they realize the shortage of money, they will also need to contact each other and decide what strategy to adopt.

These three design patterns are first steps toward designing motivating and educationally rich MCLGs. However, this is far from being sufficient to get teachers to use MCLGs in their class. Indeed, not only do teachers need to feel at ease installing and using these games but their content and shape also need to be compatible with their educational context (e.g. student's level, curriculum, number of students). In the next section, we discuss solutions to meet these expectations.

3. PLACING THE TEACHER IN THE CENTER

When considering the multitude of learning applications developed for research, it is surprising to see how few of them are actually used by teachers. This can party be explained by the obsolescence of hardware and software but it is mainly due to the fact that the educational content and the shape of the applications simply don't meet the teacher's needs. In some cases, especially for Learning Games, the applications are designed without the presence of teachers (Ketam *et al.*, 2013). In this case, they are quite unlikely to integrate the pedagogical structure that teachers need for their courses. In most cases though, learning applications are designed with the help of one teacher but they are therefore tailored for that specific teacher and one particular educational context. Because these applications leave very little room for adaptation, without any computer skills, they often cannot be used by other colleagues or even by the same teacher but with another class (Marne *et al.*, 2013). This rigidity causes most applications to be put away and forgotten after just a few years. Another reason that can explain the fact that learning applications are rare in school is that they are often set up by professional computer scientist and, unless the teachers are very skilled with computers, it is highly improbable they will be able to set them up again if there is a technical problem or if the school is provided with new computers and mobile devices.

In order to get the maximum number of teachers to use MCLGs, we therefore believe it is necessary to place them in a central and active role during the design process and the use of these applications. In the next section, we provide leads on how to design tools to help teachers:

- **design** their own MCLGs and **understand** the mechanisms under the lid to adapt them
- **monitor** the student's progression in the game and **adjust** the scenario in real time
- easily **deploy** MCLGs on the available mobile devices and fully integrate them to their course

3.1 Design and Understand

Before using any kind of tool in class, teachers feel the need to test it and understand the way it works. This is a necessary step to decide if the tool corresponds to their needs and to plan how they want to use it with their students. This step is a big concern to teachers, especially when dealing with unknown game mechanics. Indeed, if it is not clearly stated, it is difficult to imagine how they can impact a course. The fear of not being able to control students when they are "frantically playing" is often enough to discourage teachers.

In order to design MCLGs that correspond to the teacher's needs, and help them understand the game mechanics, we believe it is indispensable to involve them in the design process as early as possible. In the field of Learning Games, this challenge has been answered with two different strategies. The first solution is to help teachers design games with the help of game designers. In order to help them understand each other and work in an efficient way, several authoring tools have been developed (Marfisi-Schottman *et al.*, 2010). This solution has the advantage of providing original game scenarios, custom-tailored to fit the teacher's needs however, as you can image, the services of a game expert and the development cost are not affordable by many schools. The second solution consists in providing teachers with premade game-shells in which they can add their educational content. These shells often come with more or less complex editors that allow teachers to generate their own functional applications for a very low cost, because they need little or no help from developers and graphic designers (Thiagarajan *et al*., 2003) (Mehm *et al.*, 2009) (Marfisi-Schottman *et al.*, 2013).

Because one of our goals is to widen the use of MCLGs to all types of schools and levels of education, we believe that building on the second solution is the most promising. However, in our opinion, the existing authoring tools, such as *eAdventure* (Moreno-Ger *et al.*, 2008) and *Storytec* (Mehm *et al.*, 2009), are fare from answering the teacher's needs and there is still quite a few improvements to make. The most important drawback is the very limited selection of game-shells that exist. Providing game-shells that correspond to the MCLG patterns we proposed in the second section of this article would be a good start to address this issue. The existing editors also lack flexibility and it is very difficult for teachers to compose a scenario that fits exactly to their needs. Finally, we believe authoring tools also need to provide information on the game mechanics and the education situations that they create, in order to help teachers choose the right games and use them correctly.

3.2 Monitor and Adjust

When giving a course, teachers naturally adapt the content (e.g. formulation of sentences, order of exercises, adding questions) depending on the student's achievements and emotions (e.g. facial expressions). If we want teachers to feel at ease with MCLGs, they must also provide them with feedback on the student's actions and allow real-time control over the events.

For this purpose, Carron and Marty (2012) recommend using monitoring tools that enable teachers to view the progression of their students through the game. Because students might be running around in the fields when using MCLGs, these tools could also provide information on their physical and logical location. They could also show large grain information such as "student needs help" or "student is in advance" when certain patterns are identified in lower level data, collected from the GPS tracks, scoring and feedback.

We believe teachers should also be able to adjust MCLGs' scenarios when they identify a problem. These adjustments can be done for one student in particular (e.g. sending a hint or an extra quest) or for all the students by adapting the global scenario (e.g. stopping the game, deleting a part of the scenario). In any case, given the mobility of MCLGs, teachers should have the means of communicating with a particular student or with the entire group at the same time. The intervention of teachers is also a good way of making game scenarios more interesting and unpredictable. In *Laboratorium of Epidemiologie* (Ney *et al.*, 2010) for instance, the students are not aware that one of the important characters is piloted by the teacher. Not only does this allow the teacher to subtly adapt the level of difficulty to the student's profile but the students also seem to accept negative comments coming from the game characters much better than if they came directly from the teacher. In certain cases, it might also be interesting to let teachers pilot the whole scenario of events depending on the student's reactions. For instance, Ponder *et al.* (2003) designed a simulator in which the students have to provide first aid care and, depending on the actions of the learner (e.g. moving the body, heart massage), the teacher triggers other events (e.g. person goes unconscious, starts bleeding). The idea is to adjust the scenario so that is pushes the student into a stressful state.

3.3 Deploy

The execution of MCLGs is a real challenge of its own. Indeed, these applications not only need to be functional on various mobile devices but the content collected during the field expedition must be easily transferable to desktop computers in order to be further analyzed and used as course material (George and Serna, 2011). Ideally, if the teachers use a LMS (Learning Management System), their student's achievements in the game should also be added into this system. We believe the new Tin Can API[2] seems to fit the purpose but needs to be further tested. Indeed, this API allows collecting data about the wide range of experiences a person has from various inputs (e.g. LMS, mobile applications, social networks, Web activity).

In order to support collaborative scenarios and their real-time adaptation by teachers, MCLGs scenarios also need to be executed by a centralized game engine that orchestrates the activities depending on the learner's actions and roles. Such a flexible orchestration could, for example, be possible with IMS-LD[3] modeling. Indeed this E-learning standard is recognized by course designers and executable by many online tools. However, it has been criticized for the difficulty of modeling collaborative activities and its level of abstraction too far from teachers' practices. One of the future research challenges is therefore to propose a model for designing MCLGs, that can be easily understood and manipulated by teachers, and that can also be transform into an executable IMS-LD model.

4. CONCLUSION

In this article, we discuss the way *collaboration*, *game* mechanics and *mobility* can engage students and enhance their *learning* process. We also show that, when these three mechanics are combined in a MCLG (Mobile Collaborative Learning Game), they create synergies and should therefore be even more effective. However, for the time being, there are no tools or methods to help teachers design and use MCLGs in class in such a way to obtain these synergies.

In order to address this issue, we first provide three game patterns that can be used as models for designing MCLGs: live action role-playing games, mystery games and treasure hunts. These patterns naturally create the synergies between collaboration, game mechanics and mobility and fit a large range of educational goals such as understanding complex mechanics, practicing professional skills in the real context and learning about situated objects and environments. We then put forward the challenge of making teachers use learning applications, such as MCLGs, in their class. We believe the best solution is to involve teachers as early as possible in the design process of MCLGs and also provide them with tools to monitor their student's actions and adapt the game scenario in real time. As a first step toward the technical deployment of MCLGs, we also identify the existing tools that could be put together in order to obtain a game engine capable of multi-platform execution, multi-role scenarios, real time scenario adaptation and exporting the data collected on the field to be used as course material.

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