Toward Rapid Prototyping Tools for Designing Collaborative Learning Activities on Tabletops

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Abstract

Digital multi-touch tabletops are gaining increasing relevancy within commercial and educational sectors, as they can favor collaborative learning by enabling simultaneous interactions of several users and engaging users in the activity. They are particularly interesting for two levels of collaboration: collaboration at the tabletop and collaboration through tabletops. Our research interest focuses on exploring the potential of multi-touch tabletops regarding these different levels of collaboration to favor learning. We are particularly interested in serious games which are increasing and gaining more attentions in recent years. However, their design process is costly and time consuming. The main goal of this research is to design an authoring tool for serious games on multi-touch tabletops, which will allow non-experts to create mini-games for learning in an efficient and structured way.

1. Introduction

In traditional computer-supported learning, there are limited face-to-face and synchronous collaboration since one-person/one-computer pattern is most of the time adopted. Some researches that confirmed that collaboration is an important feature for learning as it holds the promise of conductively exploring and sharing information and knowledge (Gokhale, 1995; Harasim et al., 1995; Koschmann, 1996). On account of this, multi-touch tabletops, which hold positive influences in students' collaboration by providing shared physical displays, are gaining attention from researchers (Scot et al., 2003). Students can carry out collaborative activities meanwhile keeping face-to-face communication. In previous work, two levels of collaboration related to tabletops have been established: 1) collaboration through tabletops and 2) collaboration at tabletops (Schubert et al, 2012a). Our research interest focuses on enhancing these two levels of collaboration to favor learning. Moreover, tabletops are also well adapted for highly interactive applications, such as serious game (George et al., 2014). Nevertheless, the design process of serious games are costly, time-consuming and requires a large numbers of specialists from diverse domains to collaborate (Marfisi-Schottman et al., 2010). Considering this, the main research goal of this Ph.D. consists in providing tools to support rapid prototyping and designing an authoring tool for collaborative serious games on multi-touch tabletops which can help non-experts to create games rapidly and efficiently.

In the following sections, we will firstly introduce collaborative learning and the technologies that support it. Then we will describe the concept of serious games, their design process and several related works. Lastly, the proposition of this Ph.D. project will be presented, including research issues, the main features and the framework of the authoring tool.

2. Computer-Supported Collaborative Learning

Collaborative learning is “a situation in which two or more people learn or attempt to learn something together” (Dillenbourg, 1999). Unlike individual learning, it involves individuals as group members to share information, respect others’ abilities and make their own contributions. Collaborative learning significantly transforms the traditional teacher-centered classroom to the student-centered learning communities which involves joint intellectual effort by students and teachers together (Smith & Macgregor, 1992). It accumulates individual experiences, meanwhile keeps students aware of the whole group which promotes ideas-sharing and team-working (Haythornthwaite 2006). Laal and Ghodsi summarized the benefits of collaborative learning into four major categories: social benefits (establishing positive and social support learning communities), psychological benefits (realizing self-worth by making contribution to the group and reducing pressure), academic benefits (promoting critical thinking skills and improving classroom results) and different assessment techniques (assessing from both teachers’ and students’ standpoint) (Laal & Ghodsi, 2012). Thus, collaborative learning is definitely a positive education approach for teaching and learning.

In order to enhance collaborative learning applications, different technologies and methodologies have been studied, such as new tools to support collaborative activities, creations of more interactive learning environments and constructivist-based methods for
teaching and learning (Resta & Laferrière, 2007). Among these, multi-touch interactive tabletops, which have a computer interface that resembles a table, attract increased attentions from CSCL (Computer Supported Collaborative Learning) researchers (Dillenbourg & Evans, 2011). This advanced technology, with specific affordances, presents potential advantages for collaborative learning. For example, it provides a shared physical display where tasks can be represented to all the students at the same time. Moreover, it has a horizontal interactive display which is better than the vertical display by facilitating on more roles switches and greater awareness of others actions (Rogers & Lindley, 2004). In addition, its multi-touch interactive interface allows several users to interact simultaneously. To detect different kinds of interactions on multi-touch tabletops like the position of fingers and the tangible objects, a variety of techniques have been developed such as the capacity grids, cameras capture and RFID readers. Figure 1 shows the example of interaction between tabletop and tangible objects (Hervault, 2013).

Figure 1. Interaction between tabletop and tangible objects

Besides that, the tabletops can also be given the abilities to communicate with each other, or with other devices such as tablets, interactive board, smartphones, etc., which can augment the diversity of the collaborative activities in learning. Figure 2 shows an example of an interaction between a tabletop and a tablet (Geogre et al., 2014). The digital objects can be passed between the tabletop and the tablet to accomplish specific purpose.

These features allow multi-touch tabletops to have a specific educational favor. However, as Dillenbourg and Evans discussed (Dillenbourg & Evans, 2011), we cannot expect that tabletops improve teaching and learning in every situations. Many researches have been done in the last few years to study the performance of tabletops and their impact on learning. For example, in the SynergyNet project, several networked multi-touch tabletops were deployed in a classroom environment in which children could undertake a history task of a mining accident (Higgins et al., 2012). The experimental results showed that in such task, allowing groups to interact with the surface at the same time is supportive of collaborative interaction. The Tinkerlamp is a tangible tabletop environment which is developed for training apprentices in logistics (Do-Lenh, 2012). The researchers found out that using complementary interactions such as tangible objects and augmented paper could support for more teachers’ orchestration and more students’ reflection which in turn resulted in improved learning outcomes. The experimental results meanwhile showed that the physical manipulation with tabletops might trap users and neglect high-level discussion as too much manipulation would lead to a failure for group to step back and reflect, which indicated that the balance between manipulation and reflection was a critical role in the learning process. In the TATIN-PIC project, a table-centric collaborative environment which is composed of an interactive tabletop and an interactive board is built to explore the preliminary design phase beyond brainstorming. It drew the conclusion that in the brainstorming sessions, a digital tabletop environment could lead to more communicative gestures and promise an equitable contribution among group members. Kharrufa and his colleagues have developed the “Digital Mysteries”, a collaborative learning platform for class which could be used on digital tabletops. They evaluated this platform and proved that using digital tabletops in class had a better performance on collaborative learning than traditional learning approach (Kharrufa et al., 2010). They also tested multiple digital tabletops in classroom to study challenges that designers may meet in the development and provided design recommendations for future tabletop applications for classroom (Kharrufa et al., 2013). In addition, in the SEGAREM (SEriousGAmes and Mixed Reality) project, tabletops were used to evaluate the added value of the mixed reality on learning by combining with tablets, smartphones and physical objects. The result showed that adding mixed reality on learning can help student to obtain positive learning outcomes on practical aspects whereas to manipulate more and reflect less which was coherent with the study in the SynergyNet project. These researches reveal that tabletops present coexisting benefits and certain disadvantages when applied with
different configurations in diverse learning environments.

3. Serious Games Design Process

Serious games are games designed for the primary purpose other than mere entertainment (Susi, et al., 2007). They take the advantage of the power of computer games to realize specific purposes, such as developing new knowledge and skills, by engaging and motivating users. They can also offer virtual environments for users to develop professional skills which are impossible to experience in real world for different reasons, such as cost, safety, etc. (Corti, 2006). Owing to their advantages for training, serious games have been used in broad spectrum areas such as education, healthcare, scientific exploration and military. Among these areas, we are interested in learning game, which is a subset of serious games dealing with pedagogically based applications that used for accomplishing learning activities (George & Serna, 2011). Applying learning games on multi-touch tabletops can potentially favor collaborative learning by adding highly interaction and motivation.

Even though learning games present advantages for education, they have not been widely used due to their complex and costly design process. For example, a learning game needs pedagogical experts for the definition of game contents in order to achieve the pedagogical objective and educational value. Game designers and graphic designers are also involved in the design process to ensure the game to be consecutive and attractive. Above all, the programmers are needed to realize game engine and the expected functionalities. In view of these, the design process of a learning game needs specialists from various domains to work together. Nevertheless, in most of the learning situation, we only have teacher as the only actor. It would be useful to provide them, or non-experts who want to design learning games, an authoring tool which allows them to create a simple learning game by themselves using different technologies (in particular tabletops), and change the game contents easily depending on their various needs, such as teaching, training or researching. To minimize the risks in the design and development process, it is helpful to test ideas and technical aspects at an early stage. Rapid prototyping is a fast and efficient approach that helps designers to shorten the time on testing ideas and implementing possibilities (Ollila et al., 2008). It is important to provide rapid prototyping tools so that designers can make choices and take decisions in the early phase, in particular regarding the platforms or technologies that can be used to favor collaboration.

Nowadays there are already some authoring tools for learning games. For example, the “StoryTec”1 is an authoring tool for adaptive educational games which combine visual programming approach and high-level logic for authors (Mehm et al., 2012). It provides a “drag and drop” creation method to create digital storytelling learning games which can be published both on PCs and smartphones. The “Digital Mysteries” 2 that we described before also offers an authoring tool that allows teachers to create mysteries from scratch or edit existing mysteries in their permanent library. These mysteries can be run on tablets, standard PCs or tabletops. The “eAdventures” 3 authoring tool is used for creating educational point & click adventure games, which also uses graphical editor method. The final application can be a standalone application or an applet for online education. “LEGADEE” 4, designed by Marfisi-Schottman, provides a platform for teachers and game designer to detail all the necessary information of the learning game. Each of these authoring tools focus on a specific approach for learning and are aimed to develop complete games. Most of them focus on the pedagogical scenario specifications and do not consider, or not much, technological aspects.

4. Research Issues and Proposition

4.1 Research Issues and Methodology

As explained previously, the design of learning games is costly and involves various stakeholders. It can be especially sensitive when new technologies, such as tabletops, smartphones, etc., are used. Some rapid prototyping and authoring tools are required to make the design process easier and interactive. These tools should be considered as tools that 1) enable to test very quickly different configuration options, and 2) allow designers of serious games to take decisions regarding different pedagogical aspects and above all technological and interaction aspects. In this perspective, we chose to focus on a particular kind of learning games, called mini learning game, which has several advantages for design and test. First of all, the creation of a mini learning game is quite simple for users who are lack of technical experience as it does not have intricate scenarios or mechanics. Secondly, mini learning games can be useful for learning even though they do not have complex scenarios (Prensky, 2008) and they can be easily applied in the classroom. Moreover, as games can be created simply, it means that the test and evaluation of them can be done quickly. Above all, mini learning games are flexible and reusable. We can combine them to build a larger game or embed them into an existing game. In view of these, the authoring tool for mini learning games can be efficient to design in order to test different configurations to explore collaboration issues. The mini-game developed with such authoring tools could possibly be used and integrated in more complex serious games.

1 http://www.storytec.de/
2 http://www.reflectivethinking.com/digitalmysteries
3 http://e-adventure.e-ucm.es/
4 http://liris.cnrs.fr/legadee/
There exist some authoring tools for mini learning games. For instance, the “Thiagi group”\(^5\), is a group of people who design succinct training games based on people’s demands by using game framework (“jeux-cadres”). “CarrefourJeux”\(^6\) is a web-based authoring tool which contains different kinds of mini learning games such as Parcheesi, Mother Goose Game and Tic Tac Toe game. These game scenarios can be changed according to the learning content. “Glup”\(^7\) is an online tool that allows users to transform learning contents into mini-games. Each game can be customized designed, like different dimensions and difficulty levels, and downloaded or published on the website.

According to the research on existing authoring tools, we found out that there isn’t an authoring tool for highly collaborative mini game for learning on tabletops. We propose to focus our research goal on it to fill this gap. The aimed authoring tool will simplify the design process and allow non-experts to create mini-games on tabletops in an efficient and structured way. Besides that, the created mini learning games will also involve different levels of collaborations.

Thus the main issues of this Ph.D. project can be summarized as these two questions:

1. How to design an authoring tool for learning games that meets users’ demands and allows rapid prototyping and testing.
2. How these created learning games on tabletops could encourage different levels of collaboration.

From a methodological point of view, we will adopt a user-centered design approach, by observing the different users of learning games design. At the same time, the analysis of the different existing collaborative learning games using tabletops should help us to extract the main features that should provide such rapid prototyping tools regarding collaboration aspects.

### 4.2 Main Features

As we described in the former section, there are two levels of collaboration in the learning activities that can be exploited on tabletops. Figure 3 shows a brainstorming session which refers to collaboration at tabletop (Schubert et al., 2012b). Figure 4 presents a role playing game aiming to improve the performance of a production line which involves collaboration through tabletops (George et al. 2014). The former researches argued that enhancing different levels of collaboration in CSCL environment can have potential positive impacts on learning (Schubert et al., 2012a). Our authoring tool will have a module to configure the collaboration pattern in learning activities such as which task can be finished on a single tabletop and which task should be finished with the help of other tabletops. It can also help users to set rules for territory on tabletops to distribute shared and private spaces. Other devices could be applied into the learning environment including tablets (as shown in Figure 2) and smartphones to add the mobility and diversity into the collaborative interaction. Users can specify the user interface distribution according to these devices just by choosing the options from the module.

Using tangible objects in the leaning activities will also be considered in this project. Tangible user interfaces (TUIs) have potential benefits for learning such as providing physical information, increasing usability and improving collaboration (Do-Lenh, 2012). Nonetheless, they are still rarely used in formal learning environments. One reason is that the learning environment is a complex ecosystem which has many constraints, bringing a new technology into may disrupt its fragile balance. Our

\(^5\) http://www.thiagi.fr

\(^6\) http://www.savie.qc.ca/CarrefourJeux2/Accueil_content.asp

\(^7\) http://glup.crdp.ac-versailles.fr/
authoring tool provides a solution to improve this. It allows users to involve TUIs into learning activities in the design process. Users can choose the objects they want from the option, give them specific meaning and set the rules of usage such as how to share objects and when to use them in turns. By this means, the learning activities with TUIs will be more coherent and controllable.

From a more technical point of view, we propose to apply Component-Based Software Engineering (CBSE) for the control. CBSE is an emerging paradigm of software development (Aoyama, 1998), aiming to split up a system into independent components which can be exploited and reused to achieve brief and clear design (Mehm et al., 2011). It has been widely used in game industry due to its performance on reducing development cost and time and improving maintainability and reliability (Cai et al., 2000). We plan to take these advantages into our authoring tool by using the module “Component Toolkit”. Users can create a game structure by selecting an appropriate component, dragging it from the toolkit and dropping it in the workplace. In order to make the creative process even easier, these components should be self-descriptive, able to communicate with each other and contain a concise interface. Users could create different kinds of mini-games for specific educational field by using and combining these off-the-shelf components. For example, with the “Jigsaw Puzzle Component”, users could create a puzzle learning games just by adding appropriate pictures into it, such as a famous painting or the world map the user can cut into pieces automatically and stacked randomly. The components could also include different levels so that users would be able easily to change levels according to students’ abilities. In addition, there should be also some assistant tools such as the “Arrow Tool” which would be used to indicate the game flow and help other components to communicate; the “Description Tool” which would be used to provide more information of the game to students, etc. These assistant tools should ensure the integrity and continuity of learning games.

These are the main features of this authoring tool. In summary, it could help users do design learning game from these aspects: specifying the devices composition of the learning environment (tabletops, smartphones, tablets, etc.), specifying the UI distribution according to these devices, setting rules for territory and objects (shared or private) and designing by using components. There features are based on our current proposition, we will improve them and keep on figuring out other useful features in our future study.

4.3 Framework

The framework that we will use is based on the former work in our laboratory which was built to simplify the development of learning games on multi-touch devices. It generates a skeleton for a web-based game where the designers can set the hardware configuration at the beginning of the design, like the number of involved tabletops or the interactions specifications (detection of fingers or/and objects, etc.). It also contains a network module that permits the communication between devices, such as tablets, smartphones or tabletops. The tabletops that we are going to use are designed by our laboratory (See figure 3). The framework is written in JavaScript and mainly based on the HTML5 Canvas. It uses the TUIO protocol to collect the multi-touch events. It also has a 2D rigid body simulation engine designed for fully dynamical applications.

5. Conclusion

Tabletop is an advanced technology that can favor collaborative learning owing to its physical shared display. It is also an applicable platform for serious games. We are interested in applying serious games on tabletops to enhance different levels of collaboration to favor learning. However, the design process of serious game is costly and time consuming. Considering this, we propose the main goal of this Ph.D. project: designing an authoring tool that can help non-experts to create mini collaborative learning game on tabletops in an efficient and structured way. We give the perspective of the main features of this authoring tool, such as the component-based development, the ability to design different levels of collaboration, the capability to combine other devices and objects into the learning activities, and the framework that satisfies the deployment on tabletops. We will design and test the authoring tool by using rapid prototyping basing on these main features which will be improved and completed during the whole process as well.

Reference


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