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Multiplayer Adventures for Collaborative Learning With Serious Games

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Abstract: The concept of Computer Supported Collaborative Learning (CSCL) has been researched for many years with CSCL being an interesting alternative to traditional collaborative learning scenarios, today. In recent years, a multitude of game-based learning applications and Serious Games have been created for various fields of application, like learning, training, sports and health. However, only very few of these games support multiple players and can be used for collaborative learning as well as for training social skills like communication and teamwork. Especially in the adventure game genre which is traditionally used for learning games, there are hardly any concepts, and even less implementations of multiplayer modes. Since adventure games offer a way to present learning content in a structured and guided way, a combination of their properties with the advantage of multiplayer games seems promising. Therefore we present an approach for designing and authoring multiplayer adventures for collaborative learning. We derived requirements for puzzle design from literature covering singleplayer adventures and multiplayer games in general. These requirements were used to describe different types of player separation as a basic concept for puzzle design. Furthermore, interfaces for explicit and implicit communication as an important factor for collaboration and the concept of adaptivity were discussed in this context.

We implemented our concepts as extensions to the StoryTec authoring environment and the StoryPlay player. Thus, non-programmer authors are able to create multiplayer adventures using StoryTec. Based on this platform we then designed and implemented a prototypical multiplayer adventure. This game was evaluated in a user-centred study focusing on the collaborative gaming and puzzles elements. Another study focused on the usability of the authoring environment.

Our studies have shown that players were able to play collaboratively in our multiplayer adventure, working together and solving puzzles as a team. The Players enjoyed the idea of playing collaboratively in a multiplayer adventure. We therefore believe that our approach may build the ground for further research in collaborative adventures.

Keywords/Key Phrases: serious games, multiplayer games, adventure games, game-based learning, collaborative learning

1. Introduction / Motivation

In today's working world, social skills like communication or the ability to collaborate in teams are essential. The necessity for these skills is a fact which has been recognized years ago resulting in collaborative learning scenarios being implemented in today's curricula at school. Another key qualification for today's working life is the use of computers and 'new' media like the Internet. 'Digital Natives' (Prensky 2001), the generation which grew up with this technology inherently possesses the required digital knowledge. Therefore, it seems natural, to combine collaborative learning mechanisms and technology.

Computer-supported Collaborative Learning (CSCL) is being researched for more than 20 years now. In recent years many forms have been designed and used in curricula at schools. Apart from traditional learning concepts and methods, game-based learning is an approach researched for many years. The idea of game-based learning is to combine methods of gaming and learning in order to use the motivation from games for learning. These Digital Educational Games (DEGs) provide lots of successful examples like Winterfest or the Global Conflicts Series.

1.1 Collaborative Learning in Multiplayer Games

There are prominent examples of multiplayer Serious Games, like SPARX, a game for therapy of depression, or modifications of existing (massive) multiplayer games enabling concurrent learning. Thus, it seems promising, to combine the advantages of multiplayer games (concurrent gaming with

friends) with the collaborative learning paradigm. However the design of such games is challenging. The gameplay has to fulfill requirements of traditional single player games (fun, narration, immersion), challenges of multiplayer games (concurrent gaming, interaction) and Serious Game design (seamless inclusion of learning content, adaptation & personalization). Furthermore, requirements of collaborative learning have to be considered, like communication, social skills or proper group setup.

1.2 Serious Adventure Games

Many of the first DEGs were adventures. Puzzles as their main gameplay element offer a natural way to insert learning content while their slower pace allows consolidation. Adventure games are usually scene-based, so knowledge can be offered in a modular way. Therefore they are a good choice for educational games (Frazer et al. 2008).

However, to the best of our knowledge, there are hardly any approaches to use this genre for multiplayer learning in collaborative scenarios. One of the main problems is that it is much more difficult to design cooperative puzzles, as noted during the development of “eScape” (Manninen & Korva 2005).

In this paper, we propose novel concepts for creating multiplayer adventures for collaborative learning. We derive requirements for puzzle design and use them to describe different types of player separation as a basic concept. Furthermore, interfaces for explicit and implicit communication as an important factor for collaboration and the concept of adaptivity are discussed in this context.

2. Related Work

Our work aims at combining adventure games with a multiplayer mode in order to facilitate collaborative learning.

2.1 Collaborative Learning / Gaming

Collaborative learning is a concept being researched for several decades (Dillenbourg 1999; Johnson & Johnson 1999; Cuseo 2000) and has been established in today’s curricula.

(Dillenbourg 1999; Dillenbourg et al. 2009) provide an exhaustive summary of research on CSCL in the last twenty years, (Kollar et al. 2006) a conceptual analysis of collaboration scripts. In recent years, many forms of CSCL have been designed and used at schools, like Collaborative Writing (Onrubia & Engel 2009).

Other approaches use virtual worlds like Second Life as collaborative learning environments (Nelson & Ketelhut 2008). Also Massively Multiplayer Online Games (MMOGs) have been used as environments for collaborative learning scenarios (Delwiche 2006). (Zea et al. 2009) presented design guidelines for the creation of collaborative learning games based on the five essential elements for collaborative learning stated by Johnson & Johnson. (Voulgari & Komis 2008) investigated the design of effective collaborative problem solving tasks within MMOGs. An approach for a 3D collaborative multiplayer Serious Game for learning with freely definable learning content is presented in (Wendel et al. 2010) and a collaborative multiplayer Serious game focusing on collaboration and teamwork in (Wendel et al. 2012).

From a game design perspective, it is important to have a look at learning and gaming. Designing computer games is an area with lots of standard literature (Crawford 1984; Salen & Zimmerman 2004). Designing Serious Games is a narrower field. (Kiili 2005) proposed a gaming model for educational games whereas (Said 2004) proposed a model especially for children. (Harteveld 2011) describes challenges and approaches for Serious Games design.

2.2 Adventure Games

Nelson (G. Nelson 2005) outlined a game design process specifically aimed at adventures. (Luban 2002) discusses how puzzles should be integrated into (action-)adventure games.

In order to reduce design effort, some approaches exist towards automated puzzle generation during game creation (Iosup 2009; Sullivan 2009) or runtime (Magnusson & Doherty 2008). However, it still has to be shown that generated puzzles possess enough quality for educational adventure games.

2.3 Multiplayer Adventure Games

(Manninen & Korva 2005) implemented *eScape*, an adventure with some puzzles that force collaboration. He drew several conclusions regarding multiplayer puzzles from his evaluation. (Kim 2005) gives some ideas on how multiplayer puzzles could work in general.

One of the few examples for commercially available multiplayer adventures is *Myst Online: Uru Live*, which contains *Massive Multiplayer Online*-Aspects. However interaction between players takes place in designated spaces and almost all puzzles can be solved alone. *Broken Sword* simply allows a second controller for the same character.

In other adventures one player has to switch between multiple characters because they differ in skills (*Maniac Mansion*), location (*Secret Files: Tunguska*) or time period (*Day of the Tentacle*). However, if one would bind each of these characters to a different player, there is no guarantee that the "workload" is evenly distributed between them. This shows the need for specifically designed puzzles.

3. Concept

There are several game modes for multiplayer games: competitive, cooperative and collaborative (Zagal 2006). In this paper, we focus on collaborative games because of their application for collaborative learning. A naïve way to realize this would include players acting in the same space and solving the same puzzles. However, this would make collaboration optional, so it is possible that one player does all the work while the others benefit from his progress (*free riding*) and possibly miss some learning content. There is also no guarantee that the benefits of collaborative learning apply or that social skills are developed. To prevent this, the puzzles must be designed carefully (Zea et al. 2009). This poses additional constraints to the ones who were formulated to facilitate learning (Gee 2005).

3.1 Puzzle-design

Most design principles found in the related work about adventures are independent of the number of players. The design of the individual puzzles as the core gameplay mechanic however must be adapted to involve more players. In order to do this we combined several requirements from either singleplayer adventures or multiplayer games in general:

- The puzzles should be realistic and logical. This includes the reasons for cooperation.
- The actions required to solve the puzzles should be entertaining.
- The solutions should require equal contribution by all players to maintain motivation.
- The players should have to coordinate their actions in order to promote communication.
- Learning content should be integrated into the puzzles in an organic way.

One basic principle for multiplayer puzzles is player separation. If there is no separation, every player can see and access the same things. In contrast giving each player different information makes collaboration and communication necessary.

A possibility to restrict some actions and enforce collaboration is the concept of different character *skills*, which allow them to perform specific actions. A natural way to integrate this concept in an adventure game could be two characters, where one is strong and the other relatively small. Only the first character would be able to move heavy weights. The second one would be responsible for exploring tight spaces. In this setting a puzzle where a heavy object has to be used as a stepladder in order to reach a tight hole in the wall would involve collaboration between both players.

A more literal way to separate the players is to restrict them to different locations in the game. This approach can be used to limit or prevent the exchange of items without making it feel artificial, for example if one player fell into an underground cave. In multiplayer, both locations should be relatively big and interesting so that the players are able to explore while waiting for their partner. Puzzles could evolve around combining objects found in different locations, including both players equally. Special

cases of this theme are time-travel-puzzles, where the players visit the same place in different time periods. Changing something in the past will affect the future, allowing a unidirectional flow of consequences. This could be useful in games where the learning content includes long-term-effects.

While in some scenarios separation might be fixed, a free variation is also possible (Figure 1). Here, the players are able to choose roles / location according to their preferences and abilities. However, the designer cannot be sure anymore which player did what, which can be a problem if he/she wants to deliver a specific learning content. One way to circumvent this would be to dynamically adapt the game.

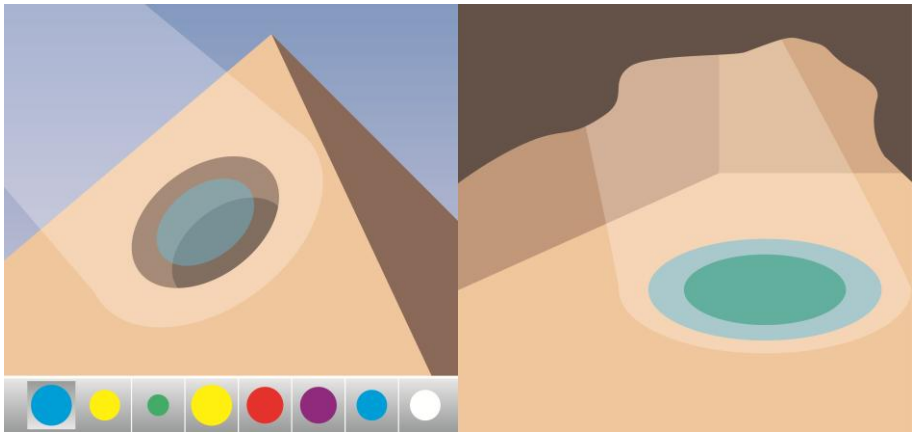

Figure 1: Puzzle with free player separation. The pyramid chamber on the right is secured by a mechanism that requires a specific kind of light (color, diameter) falling on the floor. On the roof is a small opening where sunlight falls through and the players can place different kind of lenses over the hole. In order to ease the process, it is natural that one player switches the lenses while the other one stays inside and reports the current light to his partner.

3.2 Communication Interface

The communication interface may be the only means for communication between players, offering the opportunity to transfer knowledge while deepening immersion and letting the players feel some kind of togetherness (Manninen 2003). Therefore, it must allow the players to express everything they might want to talk about. Furthermore, it should be easy to use, require no extra concentration and should not feel like an interruption. If it is meant to support collaborative problem solving and learning, the interface also has to support reflection, i.e. let the players justify solutions (Baker & Lund 1997).

Explicit communication happens consciously, with the most common form being free text. Voice chat is faster and does not interrupt gameplay. The drawback is that each player needs a microphone. Semi-structured text only allows specific predefined phrases adapted to the content of the game. It restricts communication, which can be used to promote problem-solving and reflection in collaborative learning settings (Baker & Lund 1997). These restrictions however might give some players the feeling that they are limited. Pointers or annotation tools (Dimitracopoulou 2005) are symbols or texts which the players can place inside the game world to mark specific locations or objects. Important element should be easily describable and identifiable (Toups et al. 2009), which reduces cognitive load and prevents misunderstandings. In the context of slow-paced adventures, free or semi-structured text is advised. If the puzzle-design suggests that players will often reference their environment, a pointer system could be added.

Implicit communication enables players to know what the others are doing without talking. (Manninen 2003) described several kinds of communication, where kinesis for example could be seen as implicit. It describes how a player moves, which gives strong hints about a players intention, for example when moving towards a button. Implicit communication should be used as much as possible, since it requires no extra effort by the players. This allows them to focus their explicit communication on important things like strategies instead of relatively unimportant information (Toups et al. 2009). This makes the need for player avatars in multiplayer adventures evident.

3.3 Adaptivity

Adaptivity describes the ability of a game to alter itself in order to better suit a specific player and increase replayability (Göbel et al. 2009) . In the context of multiplayer adventures this adaptations should respect the preferences of each affected player, for example by averaging their player models. When conscious decisions are required, some kind of voting or consensus is required – triggering discussion and training the players social skills (Johnson & Johnson 1988). Another specialty is that the current number of players could trigger adaptations.

Adaptation can happen on two levels. Macro adaptivity may reorder or skip puzzles and scenes as long as it does not break dependencies between puzzles (e.g. if the solution of one puzzle produces an item for another one). Micro adaptivity could modify single puzzles, for example allowing different solutions.

4. Prototype / Implementation

A prototypical game was built to evaluate these concepts.

4.1 Platform: StoryTec

The authoring environment “StoryTec” was chosen as a platform for the prototype. This allows non-programming domain-experts to create learning games (Mehm et al. 2009). StoryTec also supports personalization / adaptation (Göbel et al. 2009). Furthermore, it has been shown that a commercial adventure game could be recreated using this platform (Mehm et al. 2010).

Games created with StoryTec can be played with the “StoryPlay” player, formerly "Bat Cave" (Mehm et al. 2010). This runtime environment for the “StoryEngine” supports rapid prototyping by displaying additional information like the current player model. StoryTec however – like all adventure game engines the authors could find – was created for singleplayer games. Therefore, some extensions had to be made.

The first change lets authors define for how many players their story is designed. This number is currently limited to four, mainly because designing collaborative puzzles involving more roles is very difficult for inexperienced authors. Each player can start in a different scene. Other new features involve so-called *ActionsSets* that react differently to each player, for example when only one player is strong enough to lift an object.

An action can now move only one player (independent movement), all players in the same scene (picking up an item should be visible to all players close) or everyone (calling them together). In the case of free transitions, for which target scenes are chosen at runtime according to several models, the models of all affected players must be respected. In the case of the player model the average is used as a compromise, while in the learner model the minimum was used to ensure that nothing is missed. When updating the player model the author can target the triggering player or all players (for group decisions). Similar to transitions, sounds or speech acts can be heard by one player (i.e. thoughts), all close players (normal volume) or everyone (transmissions).

In order to support multiplayer, the runtime environment was given the ability to synchronize different instances of the StoryEngine over a network. To allow explicit and implicit communication, a text-chat and an icon-based avatar system was also added (Figure 2).

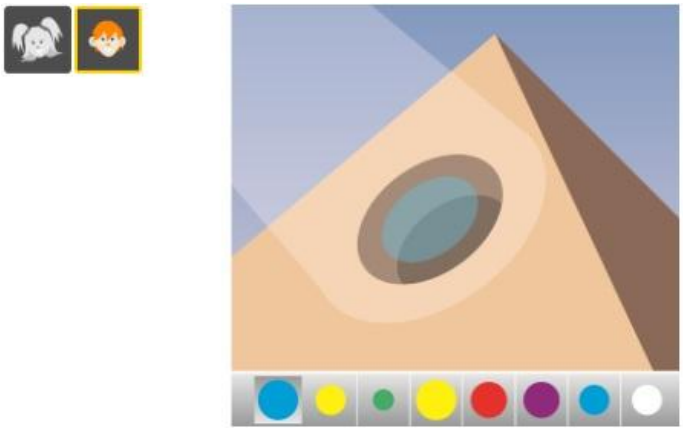

Figure 2: StoryPlay. The players' avatars are greyed out if they are in different scenes (upper left).

4.2 Selected concepts

Since it was impossible to implement all concepts developed in Section 3 due to time and platform constraints, only a subset was chosen for the game. Because teamwork is most promising for learning, all puzzles were designed for collaboration of two players.

Almost all types of player separation were used, namely skill-based and fixed / free location-based separation. The time-travel-variation was ignored for realism reasons. Since it was assumed that the players would not be familiar with the concept of multiplayer adventure, a hint system was used to encourage teamwork ("This is too heavy for me, but my partner might be able to lift it").

4.3 Game

The focus of the short demonstrator we implemented was placed mostly on puzzle design. Other elements like graphics, sound or story were kept basic. The game is set in a remote research station in the jungle, damaged during a storm. It is the goal of the players to reestablish the satellite connection with the outside world. There are two characters with different skills. Jane is familiar with the location and possesses all keys, while Joe has just arrived as the game starts. Their physical appearance also differs; Jane is smaller and more agile than the bigger and stronger Joe.

Both characters start the game in different locations. Joe has just arrived outside the station, while Jane is trapped under a tree in the woods. In contrast, Joe is able to move freely through the jungle, but cannot enter the station without Jane's key. Therefore, the first task of Joe is to find Jane in order to help her, which is difficult since the jungle is designed as a maze. However, Jane possesses a map, enabling the second player to guide his/her partner. This puzzle was designed to familiarize the players with each other and the concept of collaborative puzzle solving. Its main concept is fixed location-based separation.

In one of the later puzzles the players have to enter a storage room through an air vent. Only Jane is small enough to fit in there, but she is too small to reach the high ledge. Therefore, the player of Joe has to give her a boost, forcing both players to work directly together. The main concept used here is skill-based separation.

For another puzzle the players have to sort and connect four cables, initially building a huge pile. Each player is able to choose which one they want to tackle, so that they can distribute work as they like. This is supported by the cable ends having different colors, making them easily describable.

The final puzzle includes aligning the satellite dish on the roof, which can be rotated manually. The resulting signal strength however can only be viewed from a computer located inside the building – so it is easier if the players split up. This puzzle is an example for free location-based separation and is meant to conclude the game with a demonstration of the benefits of teamwork.

5. Evaluation

While the game was evaluated in regards to the requirements formulated in Section 3, it was also checked whether the modifications to the authoring environment had an impacts on its usability.

5.1 Game

Some criteria is about the game as a whole, for example “Are there good reasons for collaboration?”. Others like “Is the contribution of each player clear?” can be aimed at specific puzzles. For each of these questions a positive and negative statement was created to check for inconsistent answers. The questions for specific puzzles were duplicated for each phase of the game and they were reordered. The answers were selected from a five-point Likert-scale.

For the experiment, two different settings were used. The first one is characterized by two players playing in the same room over a local area network (*LAN*) where the players were able to talk, but could not see their partner’s screen. In contrast, the players playing the *Internet* setting were only using the text-chat. Since players who completed the game would know the solutions, a between-subjects-approach was selected. Before the tests, the players were given a short introduction. The game was played by 24 players, equally split into two-person-teams for each setting. Most of the players were young men who were experienced with multiplayer games, so the study can only be seen as a first indicator.

For the general questions, major results include the player noticing their limited freedom, which could be resolved by adding adaptivity. Regarding communication there was a difference between both settings – players who were able to talk were more aware of their partners. Additionally using the text chat doubled playtime. Other than that the addition of multiplayer had no negative impact, for example the players did not notice waiting time because of their partner.

The results for the puzzles showed that they fulfilled most of the requirements. The puzzle with the satellite dish was perceived best, mainly because the players knew this constellation from their real life experience. In contrast the puzzle where the cables had to be connected received only mediocre scores, which could originate from the fact that it could be solved by one player alone. Only the first puzzle showed differences between the settings, players using the text chat felt less involved when playing Jane. Observation showed that in this case the Joe-players simply used a trial and error approach to save communication effort. This effect was increased since it was the first puzzle and the players were not familiar with multiplayer adventures.

5.2 Authoring environment

To test the extended authoring environment a list of ten tasks using the new features was compiled. These tasks were meant to be carried out by people who did already have some experience with StoryTec. The participants were observed and took a survey regarding the usability, based on (Prümper 1993). The same method was used with a previous version of StoryTec.

The survey was taken by five experienced users. Aside from the test group being very small, several other facts decreased comparability with the older study. There was a different set of tasks and the current version of the tool included other updates as well. Therefore, the results can only be seen as a first impression and more weight was put on the comments and observations.

Observation and vocal feedback showed that all participants were able to locate the new functions quickly. They also made almost no mistakes, leading to the impression that the changes did not decrease usability for these participants.

6. Conclusion

In this paper, we proposed a novel approach for using adventure-based Serious Games for multiplayer collaborative learning scenarios. Our approach combines the advantages of adventure-based Serious Games for learning, for which up to today exist a multitude of successful examples, with the advantages of collaborative learning processes.

To facilitate this approach, we developed basic concepts for multiplayer adventures in a collaborative setting. We started by deriving requirements for puzzle design and described different types of player separation as a basis for the creation of engaging puzzles. Furthermore, interfaces for explicit and implicit communication as well as adaptation mechanisms were discussed in this context.

We implemented our design as an extension of the authoring tool StoryTec and created a short game containing based on these concepts. The prototype was received very well by evaluating players, although some improvements regarding the avatar-system and player freedom were pointed out. This indicates that the general concept of a multiplayer adventure, though rarely realized before, is promising.

Future work on this topic may include further extensions of the authoring environment as well as the creation of an extended prototype including real learning content and a more extensive evaluation. This will be an important step in order to evaluate the learning potential of serious adventure games with multiplayer modes.

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