

Collaborative Learning in Multiplayer Serious Games

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Abstract: Computer-supported collaborative learning (CSCL), using computer and Internet technology for collaborative learning scenarios is being researched for more than two decades with many established concepts and tools being in use today. Serious Games are a promising alternative and extension to traditional learning concepts with lots of examples of Serious Games for various purposes like game-based learning, Serious Games for opinion-forming or Serious Games for Sports & Health. In this paper, we want to propose a concept to combine the features of CSCL with those of Serious Games in order to develop a concept for collaborative learning in multiplayer Serious Games. Our concept will incorporate design guidelines from both the field of CSCL and Serious Games design. We further will outline two examples of 3D Multiplayer Serious Games we created using our concept as well as a concept for multiplayer adventure design for collaborative learning created with the authoring environment StoryTec.

1. Motivation

For more than ten years, the idea of using computers to support collaborative learning is being investigated. However, most of the research in the field of Computer Supported Collaborative Learning (CSCL) deals with e-learning applications or how to use (new) medias like the Internet or email to support collaborative learning.

In recent years, game-based learning has become an alternative and a supplement to traditional learning concepts. Various researches (Gee, 2003), (Prenksy, 2001) have shown that Serious Games offer a new field of application which can be utilized to support learning in many fields (learning, sports & health, political education, etc.). Today, there is a multitude of Serious Games for learning addressing different target groups. Yet most of those games are for single player use. Only a limited number of

Serious Games have been designed with multiplayer support due to the lack of concepts for multiplayer Serious Games.

Our idea is to combine the advantages of Multiplayer games, Serious Games and collaborative learning to collaborative multiplayer Serious Games.

The design of such games, however, is challenging. The gameplay has to fulfill requirements of traditional single player games: The game should be fun (Nacke, 2009), provide an immersive feeling by means of a good narration and appealing graphics and sound. For multiplayer games it is also important to consider concurrent gaming as well as interaction between players. Serious Games provide a whole new set of challenges to the design of games. One of the big challenges is the seamless combination of learning content and gaming elements, such that the learning content fits into the game without an unnatural barrier between learning and gaming (Wendel et al., 2011). Adaptation & Personalization is an important factor during the design process. It is especially difficult in multiplayer games, where players with different skill levels play together. Also, in games for learning it is not only important to adapt in terms of gaming, but it is vital to adapt the difficulty of the learning content to individual players.

In this paper we describe an approach for collaborative multiplayer Serious Games which enable game-based collaborative learning. Therefore, we developed a game design approach for multiplayer Serious Games fostering collaborative behavior among players (Wendel et al., 2012). The game design takes into account both the design challenges of multiplayer games and of collaborative learning. Our approach attempts to fulfill the requirements for cooperative work as a prerequisite of collaborative learning while following the design guidelines for collaborative games found in literature. Therefore, we take into account the guidelines for collaborative game design by (Zagal et al., 2006), which are derived from a comprehensive analysis of collaborative board games. We also use the design guidelines by (Zea et al., 2009) and the five essential elements for cooperative work as stated by (Johnson and Johnson, 1994). We combine the guidelines mentioned above to an approach to design two multiplayer Serious Games with a collaborative gameplay as a foundation for collaborative learning and an approach for using these guidelines for creation of multiplayer adventure games for learning.

The first game, *Woodment*, is a 3D collaborative multiplayer Serious Game designed for an open learning content with an integrated editor for creation on custom and freely definable learning content.

Escape From Wilson Island is a collaborative 3D multiplayer Serious Game focusing on a collaborative gameplay. The game aims at training social skills like teamwork and communication skills which are vital for collaborative learning. Players have to use their unique skills and resources for the best of the team, decide on collaborative actions and a general strategy in order to win the game.

A third approach uses a different genre: adventure games. This genre is especially well suited to include a learning content into a specially designed narrative frame, an appealing story. In our approach, we try to combine the advantages of the adventure genre with multiplayer features. Riddles and other tasks are designed in a way such that they can only be solved using teamwork.

2. Related Work

2.1. Computer-supported Collaborative Learning

The concept of Collaborative learning is being used in schools today in various forms, like joint problem solving in teams, debates, or other team activities.

Various definitions for collaborative learning exist like

"a situation in which two or more people learn or attempt to learn something together" (Dillenbourg, 1999)

or *"a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem"* (Roschelle and Teasley, 1995).

The common idea of collaborative learning is to make learners interact in particular ways such that certain learning mechanisms are triggered.

(Dillenbourg, 1999) states several mechanisms to enhance the probability of these interactions to occur. Those are:

- *Setup of initial conditions:* (group size, gender, same viewpoint vs. opposing viewpoint)
- *Role-based scenario:* problems which cannot be solved with one type of knowledge
- *Interaction rules:* Free communication vs. predefined communication patterns (see also (Baker and Lund, 1997))
- *Monitoring and regulation of interactions:* Need for specific tools for the teacher

Another important work in this sector was done by (Johnson and Johnson, 1994) which identified five essential elements which foster cooperative work in face-to-face groups. These are often cited as *"five components that are essential for collaborative learning"* (Zea et al., 2009) and should be fostered by the (computer-supported) collaborative learning environment. The elements according to (Johnson and Johnson, 1994) are:

- *Positive interdependence:* knowing to be linked with other players in a way so that one cannot succeed unless they do
- *Individual accountability:* individual assessment of each student's performance and giving back the results to both the group and the individual
- *Face-to-Face promotive interaction:* Promoting each other's success by e.g. helping, encouraging and praising
- *Social skills:* Interpersonal and small group skills are vital for the success of a cooperative effort
- *Group processing:* Group members discussing their progress and working relationships

Computers are being used for collaborative learning scenarios for many years whereas the role of the computer changed lately. In the beginnings of CSCL, the computer was

mainly used as a tool for text processing. With Internet and online technology rising, the computer was also used as a tool for (text) communication like email or chat (Stahl et al., 2006). With the development of CSCL environments, first tools for organizing a CSCL setting were available. Those tools enabled new methods like computer conferences, email panels, forums and wikis (Larsson and Altermann, 2009), newsgroups or synchronous communication tools (Holmer & Wesner, 2003). More complicated tools are tools for coordination of the creation of learning groups (Reichling et al., 2004), tools for decentralized classes (Holmer and Jödicke, 2004), for managing cooperation in large learning groups (Effelsberg et al., 2004), or for collaborative writing (Onrubia & Engel, 2009).

2.2. Game-based Learning

The motivation for using games for learning is rather old and the concept is being used in various institutions of learning (school, higher education, etc.). Oftentimes games are played at school for facilitation of various learning content. (Prensky, 2001) explained why using (computer) games for learning can be a promising approach. He argues that motivation is a key factor for learning. He further proposes to combine gaming technology with learning concepts as games can provide that motivation. (Gee, 2003) argues that *“good computer [...] games [...] already incorporate a whole set of fundamentally sound learning principles”*.

Thus, computer games are already being used in educational research in various ways from online courses (Delwiche, 2006) in Massively Multiplayer Online Games (MMOGs) or *Second Life*¹ over mods for games (Squire and Barab, 2004) or games designed specifically for learning purposes. An interesting overview of games used in classroom is provided by (Squire, 2003). Those games are mainly drill-and-practice games or simulations. Drill-and-practice games mainly use factual recall exercises presented in a playful way (e.g. many games for learning vocabularies). Simulation games try to explain how certain processes and mechanism work providing the player the opportunity to manipulate those and learn how alterations affect the simulated system. An example for such a simulation is *TechForce*². Other examples of games designed for learning purposes are learning adventures like the *BrainGame* series (*Geograficus*, *Physikus*, *Mathematikus*³) which combine the adventure genre with basic learning facts about mathematics, physics, or geography. Another award-winning example is *Winterfest*⁴, an adventure for practicing basic writing and calculation skills. Whereas all of the examples mentioned above are promising examples of how Serious Games can be utilized for learning, they are all single player games. Consequently, they are not fit for a use in collaborative learning scenarios.

¹ secondlife.com

² www.techforce.de

³ www.braingame.de

⁴ www.lernspiel-winterfest.de

2.3. Design of Games for Collaborative Learning

Apart from standard game design literature like (Crawford, 1984) or (Salen & Zimmermann, 2004), an especially interesting approach to Serious Games design is provided in (Harteveld, 2011) which covers gaming foundations, how to define the real world problem, the necessity to define the purpose of the game, and gives tips about interesting choices during Serious Games design. (Zea et al., 2009) presented design guidelines enabling incorporation of features of collaborative learning in the videogame development process based on the five essential elements for collaborative learning stated by (Johnson & Johnson, 1994). (Voulgari and Komis, 2008) investigated the design of effective collaborative problem solving tasks within MMOGs, and (Rauterberg, 2002) performed a test about collaboration in MMOGs finding out that communication is essential for effective collaboration.

(Kelly et al., 2007) describe how to create a Serious Game for teaching focusing both on traditional gameplay questions and on the integration of learning tools. To solve this problem, (Wendel et al., 2011) proposed a set of guiding principles for Digital Educational Games design focusing on the seamless integration of learning content in Serious Games. (Manninen and Korva, 2005) proposed an approach for puzzle design for collaborative gaming along with an implementation in the collaborative game *eEscape*.

3. Concept

3.1. Collaborative Multiplayer Serious Games Concept

Our approach for multiplayer games for collaborative learning is based on incorporating both design concepts from collaborative learning and from multiplayer games. From the collaborative learning point of view, our approach is based on the five mechanisms for enhancement of the probability of interactions to occur between learners in a way such that learning mechanisms are triggered by (Dillenbourg, 1999). It is also based on the five essential elements stated by (Johnson and Johnson, 1994). Furthermore, it uses the design guidelines created by (Zea et al. 2009). Based on these, we derived a concept of nine design elements for collaborative multiplayer Serious Games, which are described in detail in (Wendel, 2012, CSEDU). Those elements are

- A common goal / Group success
- Heterogeneous resources
- Refillable personal resources
- Collectable and tradable resources
- Collaborative tasks
- Communication
- An in-game help system
- A scoreboard

- A trading system

Incorporating these nine elements into a multiplayer game during the design process helps creating a game containing a collaborative gameplay. The seamless integration of a learning content is another difficult design issue which is addressed in (Wendel et al., 2011).

In the following subsections we will explain two examples of how to use our design and its elements for collaborative Multiplayer Serious Games, as well as show how it can be used to create collaborative Multiplayer adventures (for learning) using an Authoring environment like *StoryTec*⁵.

3.2. Woodment

The idea behind *Woodment* was to create a Serious Game for learning in which the learning part is an essential part of the gameplay, instead of being an interruption from the playing. Thus, the gameplay should motivate to use the knowledge provided by the game rather than the learning part being a necessary evil which eventually provides the player with some kind of reward.

A 3D 3rd person action adventure setting was chosen for *Woodment*. As environment, an island with the water building a natural border for the game world was used. Players play in two opposing teams of three players each. So *Woodment* contains both a collaborative and a competitive gameplay.

The *common goal* for the group member is to log wood faster than the opposing team in order to win the game. *Group success* is obligatory as one player cannot win alone.

Heterogeneous Resources are introduced by the role taken by a player. Each player has a unique set of game relevant options only available to him/her. For example, only the manager can assign workers to tasks and only the merchant can sell wood.

There are several add-ons or power-ups all over the map which players can *collect* in order to gain bonuses. However, these *resources* are not *tradable*.

In order to gain important *resources* for the team like workers, food or ship tokens, players can head for question orbs all around the island. There they need to answer a question which, if answered correctly, rewards them with the required resource. Questions may be answered *collaboratively*. If the player who triggers the orb is not sure about the answer, he/she may ask his/her teammates. They can discuss the question and gain bonus rewards if they successfully helped to find the correct answer.

Players can *communicate* with their teammates or even with members of the opposing team through an integrated chat.

An *in-game help system* is provided by a Game Master played by a teacher or trainer, who can help players at his/her own professional opinion.

Players are aware of the current *score* as it is always displayed in the GUI so that players know if their team is in the lead or not.

⁵ www.storytec.de

We did so far not include refillable personal resources or a trading system into *Woodment*. An earlier version of *Woodment* described more technical details is provided in (Wendel et al., 2010). A screenshot of *Woodment* illustrating the game world and the GUI is shown in Figure 1.



Figure 1: Screenshot of *Woodment*

3.3. Escape From Wilson Island

In *Escape From Wilson Island (EFWI)* we designed a multiplayer Serious Game purely for a collaborative gameplay. The focus of this game is on the teamwork aspect. Consequently, this game is designed to improve soft skills like teamwork, coordination of tasks, communication, etc.

EFWI is also a 3D 3rd person action adventure game. The narrative background can best be described as a group-based ‘Robinson Crusoe’-scenario. Four players which are stranded on a deserted island need to survive on that island to eventually find a way to escape from there.

Thus, the group has a *common goal*: survive and escape; no member of the group can survive or escape alone.

As each player starts with a unique item, the players have *heterogeneous resources*. For example, one player has an axe, he/she is the only one able to fell palms; another player has a whistle which is needed to attract herons on the island for food.

Players have three player *refillable resources*: Health, Saturation, and Fitness. Saturation and Fitness slowly degrade over time, whereas health degrades when a player is drowning or suffering from hunger. Health and saturation can be refilled by eating, fitness by sleeping.

Apart from that, players can have food (berries or meat) and fire wood in their inventory which they can give to / *trade* with other players making them a *collectable and tradable resource*.

Communication is integrated in form of a chat system where players can talk to all members of the team, only to one member, or to a subset of members.

An *in-game help system* is provided by a Non-Player Character (NPC) which lives on the island. Players can approach the NPC and ask questions whenever they are stuck. Furthermore, a Game Master can provide help directly or indirectly by controlling the NPC.

At the end of the game, a scoreboard displays the group's performance as well as the individual contribution of each player.

The main feature of EFWI is the design of the collaborative gameplay. Therefore, we designed several *collaborative tasks* which players can only solve as a team. Players, for example, need to carry palms for which they have to position on the right spot near the palm and stay close to that spot while moving the palm along the island (see Figure 2). Thus, they need to coordinate their movement. Another task is hunting herons. Players need to surround the heron and drive it over a cliff. Again, coordination and communication among the team members is of utmost importance. A more detailed description of EFWI and the design decisions are provided in (Wendel, CSEDU 2012).



Figure 2: Screenshot of EFWI with three players preparing to carry a palm

3.4. Multiplayer Adventures

As shown in Section 2, the adventure game genre is especially well suited for Serious Games for learning. We also stated that, to the best of our knowledge, there are no multiplayer adventures for learning today. In our third approach we tried to apply our concept to multiplayer adventures to combine the advantages of the adventure genre with multiplayer features.

As a first step, we extended the concept about adventure genre specific features. In order for players to have different views on facts, different access on items or pieces of information, *player separation* can be used, so that players are not always playing in the same scene. This enables the *heterogeneous resources* principle.

The main feature of adventure games are the riddles to be solved by the player. Therefore, we first put together rules for sound puzzles in adventure games:

- The puzzles should be realistic and logical
- The actions required to solve the puzzles should be entertaining
- The solutions should require equal contribution by all players
- The players should have to coordinate their actions in order to promote communication.
- The learning content should be integrated into the puzzles in an organic way; it must be broken into small, understandable parts which are connected with a matching application – the solution of the puzzle they appear in

Based on these, we developed concepts to translate single player puzzle types into a multiplayer scenario (see Reuter, 2011, p. 31-34).

We integrated these puzzles as templates into *StoryTec* which was also expanded for authors to be able to design multiplayer adventures. An inventory system was added as well as a system for players to be able to be in different scenes and for actions affecting only one player or all players depending on the author's choice. The extensions were also included in *StoryPlay*, a simple 'player' which can play stories defined within *StoryTec*.

Using *StoryTec*, we created a prototypical multiplayer game for two players based on our multiplayer adventure design. In this game, two players need to solve several tasks in order to find each other and to establish a communication in order to get help. Collaborative tasks include heterogeneous resources in form of physical attributes of the two player avatars. One character is very strong, he is the only one who is able to lift heavy objects whereas the other character is rather small, thus being able to reach tight spots in the game world. In another example, we use player separation. One character is trapped in a forest under a heavy tree. The strong character needs to find the trapped one but does not know the way. The trapped player, however, has a map and can explain the way to the other player. Here, we included separation of knowledge as well, enforcing communication among the players. The two scenes described here, can be seen in Figure 3.

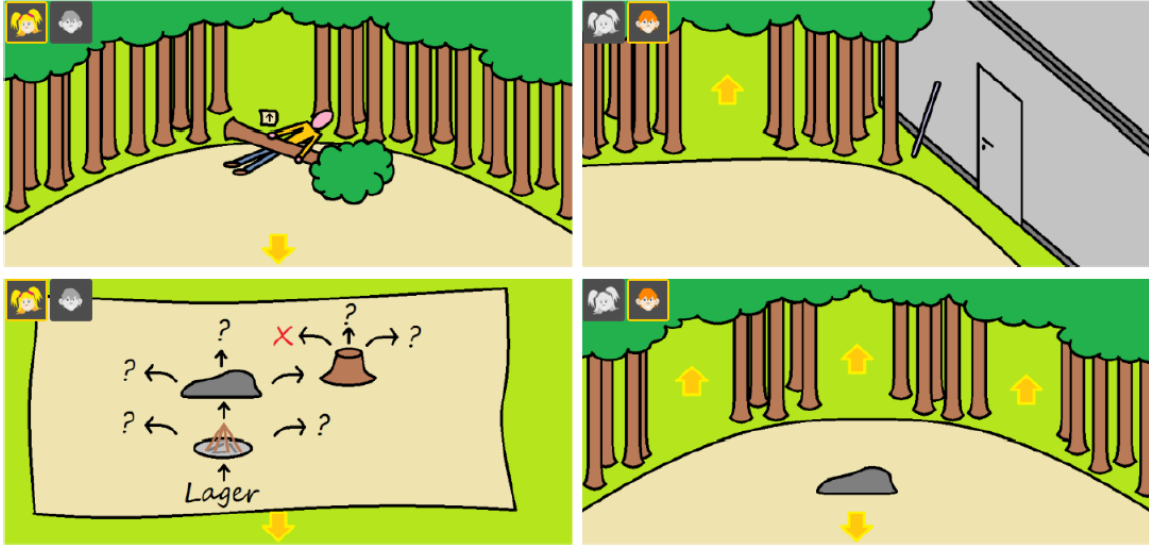


Figure 3: Multiplayer Adventure Puzzle (left: view player 1, right: view player 2)

4. Conclusion

In this paper, we argued that collaborative multiplayer Serious Games might be a promising extension to CSCL methods and concepts. We argued that collaborative multiplayer Serious Games could combine the features of both Serious Games and CSCL. We proposed an approach for designing such games based on guidelines for collaborative games and for the setting up of CSCL scenarios and for enforcing collaborative behavior in such scenarios.

We then presented three design examples of multiplayer Serious Games and their prototypical implementations. We introduced *Woodment*, a game combining learning and teamwork in a group with competition as an additional motivation. We further presented *Escape From Wilson Island*, a game for training of soft skills like teamwork, coordination and communication in teams. Finally, we proposed an approach for multiplayer adventures for learning using our design and a first prototypical game created with the *StoryTec* authoring environment.

Next steps include the evaluation of our three prototypes with real user groups. Although the learning content is not fixed for a special age, we aim at students in the age of 12-15 as many other existing single player Serious Games for learning address similar aged students. We intend to use learning content from existing school curriculums in order to be able to compare the learning outcomes with traditional learning scenarios

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