Instructor Support in Collaborative Multiplayer Serious Games for Learning
Game Mastering in the Serious Game 'Woodment'

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Abstract: In collaborative digital learning scenarios with small groups (3-6 users), the role of the instructor is vital as he/she is responsible for preparation of the setting, observation, coaching, moderation and adaptation. Currently, in multiplayer Serious Games, the role of the instructor is only insufficiently considered. Only very few approaches for integrating or supporting instructors in collaborative multiplayer Serious Games exist today, to the best of our knowledge. In this paper, we propose a concept for integration and support of instructors in team-based collaborative 3D multiplayer Serious Games. Our approach is based on Game Mastering principles known from roleplay games. It combines those principles with concepts for collaborative learning scenarios. We applied our concept to the existing 3D multiplayer Serious Game *Woodment* and tested it in a vocational school with 26 players in four groups (age: *m= 19.12; sd= 2.03*). Results indicate that an instructor using our Game Master framework to moderate and adapt the game at runtime can have a positive effect on both the players' learning success and perceived user experience. Moreover, a positive effect on players' gaming behavior can be observed.

1 MOTIVATION

Although many promising examples of Serious Games for learning are existing today, most of those are single player games.This is true even for social Serious Games (Konert et al., 2012) which are usually played alone despite asynchronous interaction with other players/friends. We believe that multiplayer Serious games can be a promising opportunity to combine the advantages of Serious Games with the concepts of collaborative learning, especially Computer-supported Collaborative Learning (CSCL). However, in (computer-supported) collaborative learning scenarios, the role of the instructor is vital. (Hämäläinen et al., 2006) argue that "*Computer-supported Collaborative Learning (CSCL) must provide instructional support*". The instructor is responsible for various tasks in and around the learning process. According to (Haake et al., 2004), page 30, those are, among others, analysis, monitoring, moderation, guidance, coaching, and intervention. However, to the best of our knowledge there are only very few approaches to support an instructor in digital game-based collaborative learning scenarios.

Our approach uses concepts from Game Mastering (in pen&paper roleplay games), collaborative learning, and collaborative gaming. In (Wendel et al., 2012a), as a first step, we proposed a model-based approach for a Game Master concept in 3D Multiplayer Serious Games. The paper focused on the interface between the game and the Game Master frontend as well as on a group model consisting of a player model, a learner model, and an interaction model. The main contribution of this paper is an extension of our model by proposing methods and concepts for providing a Game Master with the ability to analyze, monitor, coach, intervene, and adapt at runtime from inside the game. Therefore, we will describe methods for getting required information from the game to perform those tasks as well as for providing adequate methods of adaptation of the game. We implemented our extended concept as an extension to the existing collaborative multiplayer Serious Game *Woodment* (Wendel et al., 2010) and performed a user-centered evaluation at a vocational school in Germany. Our hypothesis is that an instructor using our approach can positively influence both game experience and learning outcome of players in an immersive way. The study was conducted at a vocational school in Germany with 26 students (age: *m= 19.12; sd= 2.03*).

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Results show that an instructor using our Game Master frontend to moderate and adapt the gaming process at runtime can have a positive effect on both the learning success and the perceived user experience of the players. Moreover, different effects on the gaming behavior of players can be observed like a more focused play style and a more coordinated teamwork.

2 RELATED WORK

The concept of Computer-supported Collaborative learning (CSCL) is being used in various learning scenarios ranging from learning at school, university learning, to training scenarios in corporate environment (Shell et al., 2005), (Stahl et al., 2006), (Onrubia and Engel, 2009), and (Larusson and Alterman, 2009). As stated by (Kearsley, 2000) or (Chiriac and Granström, 2012), the instructor's role is vital in collaborative learning scenarios. Instructors have various important tasks during collaborative learning sessions. (Mutwarasibo, 2013) states that "*the instructor's role in student group work is that of a guide or facilitator*". A more detailed description of instructor tasks in collaborative learning scenarios, especially in CSCL scenarios is given in (Haake et al., 2004), page 30. There, the tasks of an instructor are described as: analysis, monitoring, moderation, guidance, coaching, and intervention.

Grand challenges of multiplayer Serious Games research are: multiplayer Serious Game design, interaction and communication on game-based collaborative learning scenarios, and the role of the instructor as well as instructor support. (Hämäläinen et al., 2006) describe a concept for designing collaboration in a 3D virtual game environment. The role of the instructor concerning real-time orchestration in a 3D game is discussed in (Hämäläinen and Oksanen, 2012). Design guidelines for incorporation of features of collaborative learning in video games are presented by (Zea et al., 2009). (Wendel et al., 2010) describe the design of a collaborative multiplayer Serious Game for collaborative learning. The work presented here is based on this game.

The concept of Game Mastering as it will be used in this paper, is derived from pen&paper roleplay games. In such games, the Game Master (GM) is responsible for telling a suspenseful and interesting story to a group of players which are active parts in that story. Thus, they are able to actively influence that story, oftentimes against the GM's plan. The GM's task is to keep the story meaningful while at the same time allowing a maximum of freedom for the players without giving them the feeling that their actions are futile. Thus, it is the GM's task to unite those goals (well considered story vs. player freedom). This problem is often referred to as the Narrative Paradox (Louchart and Aylett, 2003). Therefore, the GM needs to be able to observe the game in the context of the whole story and be able to adapt his/her plan ad-hoc according to the needs and preferences of the players. These requirements are similar to those of an instructor in a (game-based) collaborative learning scenario. First concepts to formalize the work of a Game Master in order to transfer the Game Master concept to digital games have been proposed by (Tychsen et al., 2005) and (Tychsen, 2008).

Various concepts for modeling player behavior and preferences have been proposed up to today. The most prominent player model is Bartle's model for roleplay types (Bartle, 1996). A more generic model has been proposed by (Houlette, 2004). A comprehensive overview over player models is provided in (Smith et al., 2011). They provide a taxonomy of player modeling. In terms of learner modeling, the concept of (Kolb and Kolb, 2005) is one of the most prominent concepts. However, for the scope of this work, we focus on modeling the learning progress of learners. Therefore, we need to model what a player/learner has already learned. It is also desirable to be able to make suggestions for the next learning unit based on already learned content. Therefore, a hierarchical approach to modeling learner skills seems suitable like proposed by (Korossy, 1999).

3 OUR APPROACH

The approach presented in this paper is based on our concept for Game Mastering as described in (Wendel et al., 2012a). There we propose a component-based model for describing a 3D multiplayer Serious Game. Our concept defines a 'group model' to model players/learners. The group model is composed of a player model, a learner model, and an interaction model. In this paper, we want to extend that model about a client sided interface declaring how information from a game can be extracted to be presented to an instructor in a useful manner. Furthermore, the extended model defines an interface for accessing relevant game entities in order to be able to adapt the game at runtime.

3.1 Architecture

The architecture of our framework (see Figure 1) contains two main elements: One is the 3D game itself, the other one is the Game Master frontend. Via the

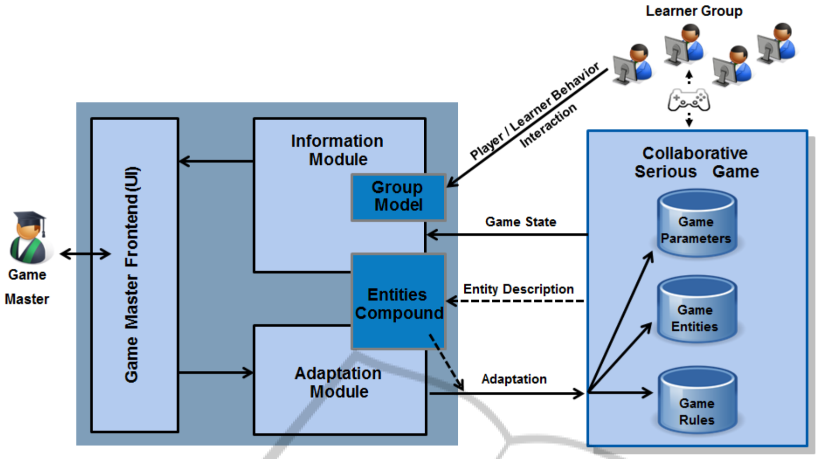

Figure 1: GM Framework Architecture

defined interface (between game and frontend), the Game Master frontend can access relevant data from the game and on the other hand adapt game rules or entities. The Game Master can use the GM frontend to receive necessary information and to influence the game according to his/her professional knowledge in order to optimize learning success, gaming experience, and collaboration. The interface is split into four sub-components: *Entities Compound*, *Group Model*, *Information Model*, and *Adaptation Model*. The components will be explained in more detail below.

3.2 Entities Compound

The *Entities Compound* defines all relevant game entities. According to (Wendel et al., 2012a), 3rd person 3D games consist of three main parts: Game World, Players, and Interaction. The *Entities Compound* describes the former two of those. It defines all relevant game entities. Relevant entities are all those game entities which's state influences the state of the game. Those are of course the player entities. Additionally, all 3D assets which have a purpose beyond setting the scene, i.e. background images, static 3D objects, and terrain. Generally, those are all game entities a player can interact with in any way. It is task of the game designer to define which game entities are relevant and which ones have only a decoration purpose. A game entity exists of a description, describing the function of the entity in the game, and a list of parameters. For each parameter the game designer needs to define if it is only informational or if it can be changed. Additionally, a parameter description needs to be provided, explaining the parameter's function for the entity.

3.3 Group Model

The *Group Model* contains the state of the group of learners. It is described in detail in (Wendel et al., 2012a). It provides information about player behavior and preferences in play style (player model). Furthermore, it describes the learning progress for each player. Finally, it contains information about interaction and communication between players.

The *Player Model* describes preferences in gaming behavior for a player, e.g. if a player prefers action, socializing with other players, or wants to experience every aspect of a game, i.e. find every hidden piece of it. The most common and best fit player model for those RPG-similar 3D multiplayer games is the player model of Bartle (Bartle, 1996). It classifies players along two axes (players - world, acting - interacting) resulting in the four stereotypical player types: killer (player, acting), achiever (world, acting), socializer (player, interacting), and explorer (world, interacting). Again, the game designer(s) need to specify which action and decision a player can take during the game relates to which player type. In our model, this is done by assigning player model modification values to relevant player actions.

The purpose of the *Learner Model* is to give the instructor a structured insight into the learning progress of players. Following the hierarchical model of Korossy (Korossy, 1999), the game designers/subject matter experts define a set of skill which will should be learned throughout the game. Those are ordered in a hierarchical structure indicating dependencies between skills. A skill depends on another skill if that other skill should be learned before this skill is looked at.

The *Interaction Model* is meant to provide the instructor with information about interaction between players. This contains any means of communication. Usually, this includes a chat protocol. A more detailed look into communication between players contains statistics about the frequency of communications between players. Apart from communication, interactions are taken into account. Therefore, the game designer needs to define which actions in a game taken by a player are an interaction with another player. This is similar to the actions defined for the player model.

3.4 Information Module

Apart from collected data like the group model, it is useful for the instructor to be able to directly observe the gaming progress (Haake et al., 2004) in order to be able to extract information about the collaborative learning process. Moreover, it might be useful for recognition of problems players might have at certain points in the game. Therefore, it seems useful for the GM to be able to move freely in the game world, i.e. have a free camera perspective. Moreover, in order to be able to spectate what all players are doing at a certain point of time when players are split up, it is useful to provide a split-screen camera. Apart from this, the GM should be provided with the information of the group model. Finally, general game parameters as well as information about the state of game entities should be displayed.

3.5 Adaptation Module

The *Adaptation Module* is the part where the instructor can influence the game by *adapting game parameters*, *adapting parameters of an entity*, and *adapting a game rule*.

Therefore, it needs access to the basic game parameters as well as to the game entities. Thus, it is connected to the *Entities Compound*. In addition to that, it needs to access the rule base of the game. As game rules significantly influence a game on a very basic layer, the game designer needs to define which rules may be changed in which way. For example, it could be allowed to perform a certain action or not. In order to simplify this access, an abstraction interface will be put between the game rule base and the *Adaptation Module*. Changing game rules can be implemented through adapting a set of (boolean) parameters, provided game rules are designed carefully. Note that learning parameters, like difficulty of questions, etc., are capsuled in game parameters or parameters of (learning) entities. However, they should be displayed to the GM in a suitable way separating them from gaming parameters. Thus, via the adaptation module, the GM is able to manipulate relevant 3D objects, game rules (i.e. interaction rules, rules for collaboration, game actions), and difficulty in terms of gaming, or learning.

4 PROOF-OF-CONCEPT

4.1 Woodment

As a proof-of-concept, we implemented our approach as an extension to the existing Serious Game prototype *Woodment*. The game has been chosen because it has a rather high level of interaction and a trainer/teacher can freely define the learning content. It is possible to create, save, and reuse question sets of various content domains and even to mix them if so wished. *Woodment* is a 3D 3rd person multiplayer digital educational game for 6 players. The game has been developed by the authors and been enhanced during practical courses or theses. One enhancement of *Woodment* was performed as a part of a diploma thesis which focused on Game Mastering concepts and team leadership (Rodenberger, 2012). Some of the visualization concepts presented in this paper have been reimplemented from this work.

Woodment as well as the enhancements implemented as a proof-of-concept for the work presented here, was implemented using the Unity3d game engine. The game can be played both in browser (Unity browser plugin required) and as a standalone application (for PC and Mac), providing us with the necessary platform independence for evaluations on varying hardware in different vocational schools.

4.2 Game Entities

Question orbs contain questions which can be triggered when a player enters the orb. They provide a game relevant resource (food, workers, or ship tokens to sell wood) if the answer is correct. The Game Master can adjust their size and movement speed as well as the frequency each question orb type spawns with. Skill canisters can be picked up in order to be able to run faster, freeze an enemy player for a period of time, or to ignite the enemy base forcing the enemy team to spend time to extinguish the fire. The GM can adjust their spawning frequency. Workers gather resources provided that they have sufficient food. They cannot be accessed directly by the GM. The player base is the center of operations for a team. The GM can view it and see if it is currently burning, but not directly adjust that fact.

4.3 Group Model

We defined several player actions like 'Pickup Skill Canister', 'Trigger Question', 'Answer Question Correctly', 'Ask For Help', or 'Help Player With Question', which affect one or more of the player model items (*killer, achiever, socializer, explorer*).

Woodment contains an integrated editor enabling the instructor to create a custom set of questions. The set of questions as well as dependencies between questions are created by the instructor according to the learning content. Thus, it is possible to model the learning space according to the Competence-based Knowledge Space theory (Korossy, 1999). The actual learner modeling is done by modeling the learners' initial knowledge and monitoring the acquisition of knowledge during the gaming phase and updating the learners' knowledge state accordingly.

All player chat is directly visible to the GM. In addition, player chats are aggregated such that for each player it is known how often he/she communicated with each other player. This is presented to the GM graphically. In terms of interaction, the game records whenever a player asks for help or gives help for a question. Also, whenever a player freezes an opponent or de-freezes a fellow player, the interaction counter for the affected players increases. This is also presented graphically.

4.4 GM Observation Frontend

To satisfy the needs for observation of the gaming occurrence, we implemented a 'fly mode' for the GM, i.e. the GM can move freely within the game world. This includes a smooth zoom. Moreover, the GM can automatically follow each player by clicking the player's name. A split screen mode was not implemented as dividing the screen into 6 parts seemed to be too confusing. The group model is displayed in a special window providing overview over each player's player model, learner model, and interaction model. The GM can view game entities directly in the game world and see their parameters in the settings window.

4.5 GM Adaptation Frontend

The GM can adapt game entity parameters (if allowed) in the settings window. Moreover, the GM can directly adjust the most significant game parameters directly on the main screen. Those are the number of wood gathered, workers, ship tokens, food, or gold for each team. Further, the GM can adapt some visual options like sunlight, brightness or fog which indirectly influence the game (difficulty). Poor sight makes finding question orbs harder which increases the need for communication among team members.

5 EVALUATION

5.1 Hypothesis and Setup

Our Hypothesis is that an instructor is able to support and positively influence the collaborative learning process as well as the game experience of a gaming session, especially the game flow. A Game Master (GM) frontend is implemented, following the concept presented in this paper. Therefore it is hypothesized:

1. Comparing with a scenario without a GM, a GM increases the flow experience and user experience.
2. Comparing with a scenario without a GM, a GM increases the learning success.

Participants were playing one of two versions of *Woodment*. The treatment group was playing *Woodment* with support of a GM, while the control group was playing the standard version without the support of a GM. Both groups were playing *Woodment* for 40 minutes and answered a questionnaire after playing the game. The questionnaire was a modified version of the user experience questionnaire described in (Wendel et al., 2012b) and includes an overall user experience (UX) score, as well as seven UX subscales. The in-game answers to the content of the curriculum were logged, too, as well as all player and GM actions. For both groups (treatment and control group), two gaming sessions with 6(7)[1] players each were conducted. Players were from different classes of a vocational school in Germany. The study includes 26 participants, 18 male, 5 female and 3 not stated. Age *m= 19.12 (sd= 2.03)*. To analyze the data an ANOVA between subjects was used. The present of the GM was used as independent variable and the overall scale, as well as the seven sub-scales were used as independent measurements.

5.2 Results

The GM version (m=6.14; sd=1.44) triggered more overall user experience (F(1,23)=6.93; p=.015) than the control group without a GM (m=4.90; sd=0.89). To detect which aspects of user experience are especially distinct in the GM version, the seven subscales were tested, too. The sub-scales Immersion (F(1,23)=7.54; p=.012), Flow (F(1,23)= 11.50;

[1]due to class sizes, in two groups we had 7 players, two students each played together on one computer

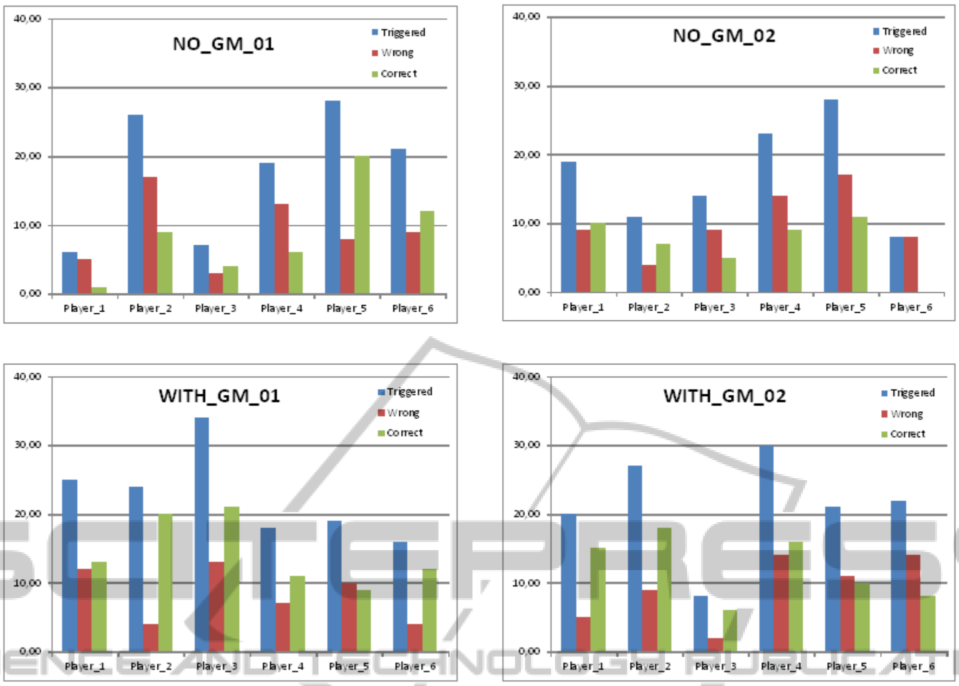

Figure 2: Questions answered by player

p=.003), and Arousal (F(1,23)= 4.25; p=.051) showed an effect in favor of the GM version.

During the gaming sessions, the game logged all relevant data. Logged data contains all GM and player actions, triggered questions and answers, chat data and all game variables logged in a one second interval. From the post-processed data we could see the progress of resources (wheat, fish, workers, idle workers, lumber, gold) for each team over time[2]. Moreover, we aggregated the data for the questions answered (see Figure 2) by the players and the player models (see Figure 3).

Figure 2 shows the number of questions triggered, and answered correctly or wrong for each player. More questions (*F(1,22)=6.77; p=.016*) have been solved correctly in versions with a GM (*m=13.25; sd=4.81*) than in versions without a GM (*m=7.83; sd=5.37*). Also, the percentage of correctly solved questions is higher (*F(1,22)=7.53; p=.012*) in versions with a GM (*m=61.21; sd=14.24*) than in versions without a GM (*m=41.58; sd=20.29*). As an indicator for the overall success of a team, we looked at the gold they were able to achieve. Without a GM, the teams got 2/2 (red/blue) and 2/3 (red/blue) gold (9 gold total among all four teams). The teams with a GM got 3/3 (red/blue) and 2/4 (red/blue) gold (12 gold total).

[2]For reasons of clarity and available space, we cannot include all of those plots in this paper. However, they are available from the authors upon request.

5.3 Discussion

Results show that both UX questions and the percentage of correctly answered questions are significantly larger in the game sessions where the GM was present and used the GM frontend. Thus, we can accept both hypotheses.

Comparing the player models, it comes to the fore in the sessions where a GM was present, players were generally more active. The values for explorer (232/254 with GM, 158/152 without GM) show that players tend to move more when a GM is present. This indicates that players were more actively searching for question orbs or supporting fellow players (e.g. de-freezing). However, as we cannot track the purpose of a movement, it needs to be clarified that higher explorer values can also mean that the respective player might just be moving around for other reasons. Achiever values (350/333 with GM, 264/238 without GM) indicate that players play more competitive when a GM is present. Collaboration values do not differ greatly (84/77 with GM, 50/84 without GM). Killers are also more active (100/134 with GM, 73/93 without GM) when the GM was present. Overall the activity (total number of actions performed)

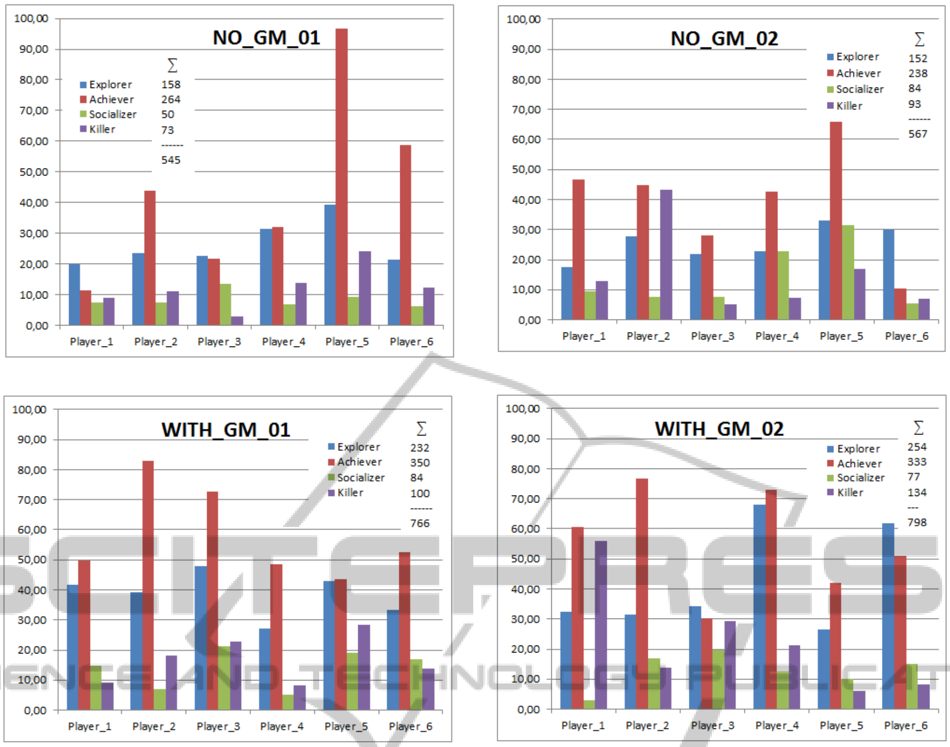

Figure 3: Player Model

was higher in those games where the GM was present (766/798 with GM, 545/567 without GM).

From the observations described above, we conclude that the GMs were able to make students focus on their tasks by reducing disturbing behavior and by recognizing problems in teams. Moreover, it seems that GMs were able to recognize problems/errors at answering questions and that they were able to provide useful help, thus increasing both the average number of questions triggered, and the amount of correctly answered questions. This indicates that the GM was able to fulfill his/her traditional tasks like observation or coaching, and help players learn better while improving UX.

5.4 Limitations

The findings of this paper are limited by the following constraints. The game sessions have been conducted with only a small number (26) of participants of which 18 ware male. Although the students enthusiasm towards playing the game and their motivation during the gaming time was seen as very positive by their teachers, it needs to be considered that this might at least partially result from the fact that playing a game was just a more fun alternative to regular class sessions. Our concept was only evaluated using one implementation for one game (*Woodment*), thus a general validity for all types of collaborative multiplayer Serious Games can not be derived.

6 CONCLUSION

In this paper we proposed a model for assisting an instructor in orchestrating a collaborative multiplayer Serious Game. Our concept is an extension to our prior work on a framework for Game Mastering in collaborative multiplayer Serious Games. It defines an interface for game developers and subject matter experts, which can use it to define relevant game entities, game parameters, or learning content. We further provide a concept for a group model based on player modeling, learner modeling and interaction modeling. Our concept addresses a suitable way of presenting relevant information to the instructor (GM) and meaningful ways of adapting the game state and game rules via the interface. We implemented our concept as an extension of the collaborative multiplayer Serious Game *Woodment* and conducted a user-centered evaluation with 26 users. Our hypothesis was that an instructor is able to use a frontend implemented according to our model in order to perform vital instructor tasks in collaborative learning scenarios and subsequently be able to improve player performance in terms of game experience and learning success. Our results indicate that our hypothesis can be accepted with some limitations. Both UX and learning performance are significantly higher in the gaming sessions where a Game Master was using the GM frontend implemented according to our concept compared to those sessions where no GM was intervening.

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