T. Koschmann, D. Suthers, & T.W. Chan (Eds.), *Computer Supported Collaborative Learning 2005: The Next 10 Years!*
Mahwah, NJ: Lawrence Erlbaum Associates.

Computer-Supported Collaboration in a Scripted 3-D Game Environment

Hämäläinen Raija, Researcher
Häkkinen Päivi, Professor
University of Jyväskylä Finland
Institute for Educational Research
PL 35, FIN-40014, University of Jyväskylä
raija.hamalainen@ktl.jyu.fi

Järvelä Sanna, Professor
University of Oulu
Finland
sanna.jarvela@oulu.fi

Manninen Tony, Assistant Professor
University of Oulu Finland
tony.manninen@oulu.fi

Abstract. The particular focus of this paper is on scripting collaboration in a 3-D virtual game environment intended to make learning more effective, but also take into account the risk of over-scripting learning. The empirical experiment eScape, which encourages learners to solve problems collaboratively, is also presented. This study attempts to find out whether the features of 3-D games can be used to create meaningful scripted collaborative learning environments. The results indicated that scripting persuaded student teams to enter into collaboration, but the actual processes varied.

Keywords: CSCL, scripting, 3-D virtual game

INTRODUCTION

To respond to learning demands, CSCL (Computer-Supported Collaborative Learning) (Koschmann, 1996) needs instructional support. Structuring the interactions taking place during the virtual learning period is one specific way to make collaborative activity more efficient. Structures that construct collaborative processes are called collaboration scripts (Dillenbourg, 2002). A part of current research on structuring CSCL is derived from earlier work on the approach based on scripted cooperation (O'Donnell, 1999). Scripts are intended to facilitate collaborative learning processes and guide learners' activities. Scripts make it possible to specify and sequence activities and roles and assign them among the members of the team engaged in collaborative work. (O'Donnell, 1999; Weinberger, 2003). Scripts may help learners to enhance the quality of their learning processes. However, designers of scripts must also take into account the risk of over-scripting learning, which may hamper natural interaction and problem-solving processes, increase the participants' cognitive load or harness their collaborative load to serve didactic purposes and purposeless interactions (Dillenbourg, 2002). Accordingly, it may be said that scripting CSCL is about balancing between helpful and excessive guidance.

Last few years have witnessed an increase in interactive gaming, though this growth has taken place mainly in the field of entertainment games. Recently, has aroused a discussion about whether collaborative virtual gaming could also promote learning. Game worlds have the potential to draw on the feeling of presence and immersion which virtual worlds can arouse at its best (Mc Lellan, 1996). More sophisticated technical applications will make avatars increasingly capable of supporting non-verbal communication between students, which may make interaction between players more efficient (Cassell & Vilhjálmsson, 1999). At their best, well-designed multiplayer games may enable engaged communication and collaboration between players during the gameplay.

Adopting games as a resource is often justified on the basis of motivational factors. However, even though games may motivate learners, there are critical issues involved in gaming. One of the major ones is that in learning, games must be put to pedagogically reasonable uses and playing must go beyond aimless enjoyment, become a purposeful activity that requires mental effort. Scripting interactions is a natural idea in game design because games are often based on different levels of activities. One possible way in which games can motivate players is the provision of higher game levels that may be reached by solving problems set in the game. For example, the higher level may offer new scope for action or give access to more tools which help the player to survive in the game. The aim of future learning games is to use scripts and different game levels in a way which supports high-level learning and pedagogically reasonable aims (Hämäläinen & Häkkinen, 2004).

RESEARCH AIMS

The study is a part of the ECOL (Ecology of Collaboration) research project, whose purpose is to examine collaborative learning as a motivated and co-ordinated activity. The eScape virtual game is a pedagogical

innovation involving the development of a technological tool intended to create settings for collaboration and increase participants' awareness of the social processes going on during collaboration. The study designed and tested game players' activities in an eScape virtual environment with the aim of finding out whether the features of 3-D games can be used to construct meaningful virtual learning environments. As regards to eScape, the aim is to answer the following questions: 1) What kind of scripting promoted collaboration in the eScape game environment? 2) What kind of interaction emerged during the game?

THE ESCAPE GAME

In eScape (Electronically Shared Collaborative and Pedagogical Experiment), the main focus was on constructing a game environment that would promote collaboration between team members and support the process of becoming a team. The game includes puzzles that can be solved only through the effort and commitment of every participant. To encourage collaborative activities, the game world consists of a small-scale thematic setting that channels and constrains the players' activities. Shared workspace collaboration revolves around certain core activities that need to be supported: 1) communication and negotiation between group members, 2) keeping track of other group members' work, and 3) stimulated physical activities such as moving tools and objects (Pinelle, Gutwin & Greenberg, 2002).

eScape is a collaborative game for four players which can be characterised as social-action adventure. The game concept involves an escape story where the group must solve a set of problems in order to flee from an ancient prison colony. It was decided to design, or script, significant key points at which collaboration was expected to take place. The scripting was hidden from the players behind the game's escape story. Due to the limited duration of the experiment, the content of the game enables approximately 60 minutes of goal-oriented activities. The players interact and experience their surroundings by using their modifiable avatars in an atmospherically captivating virtual world. Role play and player-to-player communication are supported through versatile non-verbal communication (expressions, gestures, etc) and a voice-over IP speech system which allows free spoken dialogue between the players. The main challenge in design was the scripting of motivationally guided logical and challenging problems that would require true collaboration.

RESEARCH DESIGN

This study is a design experiment, involving both the process of designing a game environment and an empirical study, where data is collected using multiple methods and then analysed, after which the findings and conclusions serve as a basis for further design work (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003). The data was aggregated and analysed at the group level. The qualitative analysis was partly theory-driven (Webb, 1989) and partly data-driven. A special laboratory environment was constructed so as to capture all the required data during the experimental game sessions. The multiplayer aspect of eScape meant that all the actions of every player must be recorded. The eScape empirical experiment was organised in 2003 with the participation of university students chosen from the non-gaming community. Six groups of four students (N=24), four of them composed of Finnish students, two of foreign students, took part in the experiment. On the first day the students were given an hour's training session in the game environment. On the second day they played the game, immediately followed by a stimulated recall interview. Data were gathered using several methods: background information questionnaires, video feed from each of the players (over-the-shoulder view), combined views from all the four players (over-the-shoulder views), video feed from a virtual camera (inside the game world, used by one of the game operators), audio recording of spoken dialogue, demo recording within the game platform (enables free camera movements during playback), observation notes, stimulated recall interviews, and the students' personal notes.

DATA ANALYSIS

After the game experiment, all the data were verified, interviews and conversations conducted during game sessions were transcribed and observation notes were sorted into categories. A qualitative analysis was carried out using data classifications. In the first stage of classification the data were categorised according to the problems scripted (key collaboration points) into the game environment. The second stage of the classification focused on the significant situations identified on the basis of the script. There were two stages. The first stage pinpointed the interactions that were the central facilitators of game progress. After this, the situations identified in the first stage were analysed to find out, on the basis of observations, what were the (individual and group) interactions that the players used, followed by an examination of their contribution to collaborative group activity (Table1).

After the building: Peter asks the other players: "So we have to look for more?". The other players answer yes, and

Peter starts to move quickly around in the game environment, carrying the box.
other players: rule-making
After the building: Peter wants to know which of the players is talking. All the same, he is operating well on his own in the game environment, carrying the box along.
identifying a target (personal)
After the building: Peter tries, alone, to use the boxes to build a platform from where he would jump over the wall and fence surrounding the castle. He does not tell any of the other players about this target.
No negotiation
After the building: Peter listens as the other players tell each other about the biting bees. Instead of going to help he continues on his own to build the platform for clearing the wall and fence around the castle.
identifying a target (personal)

Table1: An example of observations on individual and group activity

Cross-comparisons of sets of research materials collected using several methods were intended to improve the reliability of the research results.

RESULTS

According to the findings, scripting enhanced collaboration during the game. Despite the scripted environment, group and individual actions varied a great deal. The groups differed in the time spent on the game, the degree of collaboration shown, the roles assumed and the attitudes displayed by their members. Scripting guided team members towards collaboration and shared problem-solving. Despite the scripting, the time spent on the game varied from about 45 minutes to 1 hour and 20 minutes. According to the accompanying data analysis, five of the six groups had achieved good collaboration at least some points of the game, while even the non-collaborative group had managed some teamwork. The five collaborative groups followed the predefined order of scripted game tasks (Table 2).

Phase 1	Encouraging the group members to communicate
Phase 2	Planning the activities and getting to know the 3-D environment (requires *planning, goal-setting and -seeking, negotiation, co-ordination and rule-making*)
Phase 3	1st problem: getting a box from a high scaffold (requires a working plan)
Phase 4	2nd problem: getting nests from a colony of bees (requires forming dyads)
Phase 5	3rd problem: helping a blind man (requires forming groups of three or four members)
Phase 6	4th problem: firing a rocket pattern into the sky (requires *goal-setting and -seeking, planning, negotiation, co-ordination and rule-making*)
Phase 7	5th problem: constructing a hot-air balloon (requires contribution by all four members).
Phase 8	Stimulated recall and reflection (30 minutes)

Table 2: Scripted key points of the game

The game problems encouraged teams to work together. These five groups attained at least some degree of collaboration during the game although the quality of their collaboration varied a great deal even in groups immersed in game situations. For the purposes of collaboration, it was essential that the first problem the members of a team encountered in the virtual environment encouraged them to communicate with each other. Interestingly, even the non-collaborative group, reflecting on the game after its completion, felt that they had been collaborating. Collaboration emerged mostly in the problem-solving situations, and more often on the level of practical activities than on the cognitive level. The results indicate that in order to obtain collaboration it was crucial to construct tasks that compelled players to work together. In eScape, most of the problems were set in a way which made it impossible to solve them alone. However, most of the players first attempt to solve the tasks on their own, joining forces with the other players only when they realise that they are stuck. With many of the players, perceptions of collaboration clashed with observation notes: students felt that they had mostly tried to solve the problems as a team, but observations indicate that most of the players called for other players only when they actually needed their help. Only one of the six groups made, in the early stage of the game, a joint decision that they would work as a team to get through the game.

The scripted game environment enhanced the value of distributed teamwork. The players felt that they had been in the same world operating as a team, and observation notes confirmed this subjective finding. None of the teams had sensations of being alone or engaged in aimless interaction. The experiment integrated distributed CSCL and face-to-face interaction. The students met before the game, and afterwards, during the stimulated recall interview, they were shown extracts from the game video and asked to watch and comment on them. After the game the students were very eager to talk with each other about the game and find out about those aspects of the game environment that they had not understood during the game. This showed that reflection after the game was important.

During the game, the groups used different interaction processes to solve the game problems. These processes were applied mostly in problem situations and in situations where the team members were about to collaborate on the solution of a problem. All the groups **set themselves goals**, but the actual decision-making process ranged from group decisions to leader-oriented ones. The group decisions affected the game and the process of becoming a team in different ways at different stages of the game session. The players had roles although many of them were clearly not themselves aware of these, as was revealed in the interview after the game. For example, in some groups the game was dominated by one or two players who worked out the plans and told the others what to do, but in some situations leadership shifted according to the players' level of expertise. It is interesting to note that all groups felt that they had collaborated as reasonably equal partners even when the group had actually had a leader without their being aware of it. Croups **formulated low-level action plans**, but no group used much time to devise their plans. All the groups **negotiated** among themselves and **co-ordinated** their work to advance the game. In the following excerpt, there is one low-level action plan during the game.

Leila: Look, there are several places over there. How about going there all together and guiding him away from there. Tuija: I expect we'll need everyone here. Here in this place. I'll go and stand in the doorway over there. Leila: Hi there, who's there, come here. Mira: Where are you?

Throughout the game, group members **shared information** and **followed the example of each other's avatars** to further the gameplay. They shared information and learned from each other in a great variety of situations, such as when working out how certain tools functioned, how to use the avatars, what kind of individual knowledge the different players had and so on. See the following excerpt about sharing information how to use mouse.

Mira: How can I take these tools to my hand? Leila: Roll your mouse and then it will choose	9:02:46 The nest: Mira asks Leila how one uses the tools and Leila shows her how one uses the mouse to a turn. XXXX
Game situation	Observation note

During the game the groups also **made rules** on how to act in certain situations. Few of the rules were intended to limit the actions of the avatars during the game, and those made for this purpose related mostly to the last problem, which required group members to use certain tools simultaneously. All the teams also **gave feedback** and encouraged their members. There was no negative feedback in the form of personally disparaging remarks in any of the groups. The negative feedback that was given focused on the environment in situations where it did not work in the way the players expected. Feedback was most frequent in problem-solving situations and after a problem had been solved. See the following excerpt about feedback situation.

Mikko : Really close (3) Now we should be close by Juuso: Now? Yes Mika: Do you see it 13.24 (trumpets) Mikko: Splendid Juuso ( ) you are our hero	Players encourage each other
Game situation	Observation note of all players

In all groups, there were situations in which **players found it difficult to give up their own ideas** even when their proposed solution did not make sense in the game environment. In many such cases the players kept on advising each other or tried to solve the problems on their own. The most collaborative group was also the one most open to mistaken ideas. **Conflict** situations during the game were rare. When conflicts did arise it was because players did not understand or find each other. Thus, the game environment failed to create significant cognitive conflicts. However, there were occasions during the collaboration that involved tacit conflicts. For example, records show occurrences of seemingly increased levels of frustration on behalf of a player when nobody paid any attention to his or her suggestions.

All the groups **used humour** to establish relations between players even though it was not necessary for solving the game puzzles. Humour was employed to make contact with other players, survive surprising situations and liven up the atmosphere. Humour was most in evidence in those groups which had some history of being together, least in evidence in one of the foreign student groups. How much and what kind of humour there was varied both between the groups and within every group. For example, during the game the players tried to work out the similarities and differences between the game world and real world: will avatars break when they jump from a height. Some ethical issues also arose, such as whether one can open the church door using a rocket.

DISCUSSION

Our study supports some of the previous findings about essential interaction processes of collaboration, such as joint goal orientation, negotiation, co-ordination of different perspectives and information sharing (Baker, 2002; Pinelle, Gutwin & Greenberg 2002), but in game environment new forms of collaboration may also arise. In this study the 3-D game world affected collaboration, for example information sharing, because players were able to use the example of the avatars to share information. In this study, students' perceptions of a scripted game environment were very positive. Scripting persuaded student teams to enter into collaboration, but the actual processes varied. Collaboration depended crucially on team members' need for each other, because they often tried to solve the game tasks alone first. According this study scripting social modes of interaction seems to be an effective way to promote collaboration in the virtual gaming. Despite of positive influence of the scripts, there are also some critical issues such as the relationship between players' internal scripts and external scripts of the environment (Kollar, Fischer & Hesse, 2004).

The study produced encouraging results on the possibilities of edugames, but some dangers were also identified. The study indicated that it is easy to obtain collaboration on practical problems but that higher levels of collaboration are difficult to reach in a game environment. One explanation for this result is the design of relatively simplistic and secure problems, which enabled safe trial-and-error procedures. The findings show that a virtual game environment offers a setting that can, at its best, trigger several interaction modes of collaborative learning. At the same time, attention must be paid also to the variation across the groups in the quality of collaborative activity. Technology alone, does very little to aid learning. Learning crucially depends on the exact character of the activities that learners engage in with technology, the kinds of tasks they try to accomplish, and the kinds of intellectual and social activities they become involved in, in interaction with that which technology affords. Furthermore, more edugames are needed to determine the potentials and limitations of games.

ACKNOWLEDGMENTS

This research is supported by the Life as Learning research programme (LEARN) of the Academy of Finland (2002-2006) and Kaleidoscope (Network of Excellence).

REFERENCES

Baker, M. (2002). Forms of cooperation in dyadic problem solving. In P. Salambier, & H. Benchekroun (Eds.). Cooperation and complexity (pp. 1-38). Paris: Hermes

Cassell, J. & Vilhjámsson, H. (1999). Fully embodied conversational Avatars: Making communicative behaviour autonomous. Autonomous Agents and Multi-Agent Systems, 2: 45-64.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R. & Schauble, L. (2003). Design Experiments in Educational Research. Web version of Educational Researcher, 32(1), 9-14.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed), Three worlds of CSCL. Can we support CSCL (pp. 61-91). Heerlen, Open Universiteit Nederland..

Hämäläinen, R. & Häkkinen, P. (2004) Scripting Computer supported collaboration in a 3-D game environment. Paper presented in CSCL sig 2004, Lausanne.

Koschmann, T. (1996). CSCL: Theory and practice of an emerging paradigm. Mahwah, NJ: LEA.

Kollar, I., Fischer, F. & Hesse, F. (2004). Computer-supported cooperation scripts - a conceptual analysis. Journal of the Learning Sciences. (submitted).

Mc Lellan, H. (1996). Virtual Realities. In D. H. Jonassen (Eds.) Handbook of research for Educational Communications and Technology. New York, USA: Simon & Schuster Macmillan.

O'Donnell, A. M. (1999). Structuring dyadic interaction through scripted cooperation. In A. M. O'Donnell & A. King (Eds.), Cognitive perspectives on peer learning (pp. 179-196). Mahwah, NJ: Erlbaum.

Pfister, H-R. & Mühlpfordt M. (2002). Supporting Discourse in a Synchronous Learning Environment: The Learning Protocol Approach. Url: http://newmedia.colorado.edu/cscl/178.pdf

Pinelle, D. Gutwin, C. & Greenberg, S. (2002). "The Task Analysis for Groupware Usability Evaluation: Modeling Shared-Workspace Tasks with the Mechanics of Collaboration." Human Computer Interaction. Url: http://www.cpsc.ucalgary.ca/grouplab/papers/2002/02-Task-Analysis.Report/task-analysis-report.pdf

Webb, N. (1989) Peer interaction and learning in small groups. International Journal of Educational Research, 13 (1), 21-39.

Weinberger, A. (2003). Scripts for Computer-Supported Collaborative Learning Effects of social and epistemic cooperation scripts on collaborative knowledge construction Dissertation an der Fakultät für Psychologie und Pädagogik der Ludwig-Maximilians-Universität München.