Designing and evaluating collaboration in a virtual game environment for vocational learning

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Abstract

Especially in vocational education, attention should be paid not only to the use of new technological solutions but also to collaborative learning and cooperative working methods in order to develop students’ skills for their future jobs. This study involves a design experiment including the design process of a new game environment, description of the script developed for this game, as well as the empirical study with multiple data collection methods, data analysis, results and conclusions for further work. The aim of the study was twofold. Firstly, we aimed to develop a game environment to simulate the work context of a vocational design process, and secondly, to investigate how effective the game environment is in vocational learning and how scripting affected students’ group processes during the game. It seems that, at their best, such “edugames” may enrich learning and the pedagogical use of technology. Although integrating learning and games provides tempting possibilities, it also contains many challenges, such as different group-specific learning processes despite the scripted environment.

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1. Introduction

Shared activities within the frame of distributed or distant working over computer networks will play an increasingly important role in the future not only in the field of learning but also in working life. Therefore in work organisations, hope is placed on CSCW (Computer-Supported Cooperative Work) (Dourish & Bellotti, 1992), and on school contexts CSCL (Computer-Supported Collaborative Learning) (Koschmann, 1996). The current research on collaboration and cooperation in virtual environments stems partly from earlier work on group-based learning approaches (Strijbos & Martens, 2001).

Even though cooperative work and collaborative learning are related and have partly shared roots, the processes are different. The differences between CSCW and CSCL include, for example, that in school contexts as opposed to working life the methods and rewards are different. Cooperation and collaboration differ from
each other in terms of task setting and coordination. In cooperation the task is split into subtasks and each participant is responsible for a portion of the problem solving according to the division of labour, while in collaborative situations the participants are mutually involved in the shared activities and must coordinate their efforts to solve problems together. In cooperative settings learners also often produce separate solutions, whereas in collaborative learning constructing a shared solution is essential (Aronson, Blaney, Stephin, Sikes, & Snapp, 1978; Dillenbourg, Baker, Blaye, & O’Malley, 1995; Roschelle & Teasley, 1995; Weinberger, 2003). In working life cooperative work typically takes place between professionals, whereas in school there is a teacher who structures the activities and goals, and learners are novices in the study field (Stahl, 2004). Although the teacher often has an active role in collaborative learning situations, that role varies because learners are expected to interact actively with each other so that there may be little need for teacher intervention.

In vocational learning, attention should be paid not only to cooperative working methods but also to collaborative learning processes in order to develop students’ skills for their future jobs, which are likely to call for different types of group work. Even though the need for these kinds of activities is increasing, they are not without problems. Group work is especially challenging in virtual environments where the team members are often separate in time and space, which easily hampers their communication. On the other hand, at their best, virtual environments provide a shared forum not only for access to a variety of online resources but also for content issues, bringing people together to meet and create new ideas (Holmes, Lin, & Brandsford, 2001).

2. Scripting computer-supported collaboration

In collaborative learning interaction relies rather on “natural” interaction between team members usually without predefined interaction structures, whereas cooperative interaction certain design structures are traditionally used to facilitate group performance (Derry, 1999; O’Donnell, 1999; Strijbos & Martens, 2001). Latest studies have pointed out that collaboration does not emerge automatically when a group of people is operating at the same virtual environment (Arvaja, Häkkinen, Rasku-Puttonen, & Eteläpelto, 2002). Therefore, something needs to be done to improve the interactions and learning results in CSCL. Recent studies have indicated that some amount of structuring may help teams achieve effective collaboration (Kollar, Fischer, & Hesse, 2003; Lehtinen, 2003; Lipponen, 2000). However, collaboration is by no means easy to structure. There is a risk of over-structuring learners’ interactions so that their “natural” interactions and problem-solving processes may be disturbed, interactions may become too didactical or distracted from the actual goal, and finally the cognitive load for the learners may increase too much (Dillenbourg & Jermann, in press).

One way to structure collaborative processes employs so-called collaboration scripts (Dillenbourg, 2002). Such scripts are intended to facilitate collaborative learning processes and guide learners’ activities. In scripted collaboration, the participants are supposed to follow directions and undertake shared learning tasks (Weinberger, 2003). There are different approaches to scripted collaboration; the emphasis may be on the learning process itself or on representing knowledge (Pfister & Mühlpfordt, 2002). Furthermore, in CSCL environments scripts may also support the development of emotional, metacognitive, and motivational components of learning (Kollar, Fischer, & Hesse, in press). Recently, two different types of scripts have been identified in CSCL. Firstly, scripts may instruct learners in how to deal with their task (epistemic collaboration scripts) in the virtual environment. Secondly, scripts may tell the participants how they should interact with the other group members (social scripts) in the virtual environment (Kollar et al., in press; O’Donnell, 1999; Weinberger, 2003; Weinberger, Fischer, & Mandl, 2003).

According to latest studies, social scripts (intending to enhance team cohesion and collaboration) are an effective way to give instructional support for group activities (Hämäläinen, Häkkinen, Järvelä, & Manninen, 2005b; Stegmann, Weinberger, Fischer, & Mandl, 2005). Epistemic scripts aim to structure individual knowledge construction activities by providing the learners with instructions and guidelines for actions, which may help them achieve the intended learning outcome. The original basis of epistemic scripts lies in psychological theories. So far the empirical findings from collaborative learning studies with epistemic scripts have been disappointing compared to social scripts. While social scripting seems to improve learning outcomes, mere use of epistemic scripts has not lead to essentially better learning results (Weinberger, Ertl, Fischer, & Mandl, 2005). On the other hand, some epistemic guidance toward solving the task is also needed in learning and the purpose...
of epistemic scripting is to help learners to achieve better knowledge construction than in a non-scripted virtual learning environment. Therefore, there seems to be a need for further research on the limitations and possibilities of epistemic scripts, especially with regard to complex tasks in which students are solving complicated real-life problems in social situations. Hence, scripting should always take the nature of human interaction into account and also consider the overlapping of social and epistemic scripting.

3. Scripting game environment

One important point in scripting is that the scripts must lead to pedagogically reasonable practice and the environment itself must support the idea of scripting in the first place. Studies have indicated that scripting interactions is a natural idea in game design, as games are often based on different levels of activities, and virtual game environments may thus serve CSCL needs, as well. The different levels of script can correspond to higher game levels that may be reached by solving problems set in the game. For example, the higher level may offer a new scope for action or give access to more tools that help the player succeed in the game. The aim of educational games is to use scripts and different game levels in a way that supports learning and pedagogically reasonable aims (Hämäläinen et al., 2005b; Hämäläinen, Arvaja, & Hakkinen, 2005a).

Generally, the aim of an “edugame” is often to provide students with complicated challenges related to the learning task (Kiili, 2005), although there are also other types of “edugames”. In all kinds of games it is typical of good gameplay that the story keeps the player motivated throughout the game (Costikyan, 2002). Thus computer games are often associated with the image of motivational learning (Gee, 2003; Kirriemuir & McFarlane, 2003; Ulicsak, 2005). Still, enhancing motivation should not be considered from the viewpoint of extrinsic reasons of gaming, such as attractive avatars, excitement of the game, or competition involved in the game (Hämäläinen et al., 2005a, 2005b). Rather, developers should concentrate on scripting learning tasks to the game story, so that the game world brings some added value to learning.

On the other hand, when scripting a story, the risk of too obvious and demotivating tasks must also be considered. With regard to collaborative learning the tasks should be complex enough to get learners to join resources as well as motivating and rewarding enough to bring satisfaction (Weinberger, 2003). So, it can be said that the pedagogical script of a game must be considered a wholly integral aspect of the game design and the game world. In the same vein, the story behind the script must be motivating, but also pedagogically reasonable. Scripted edugames can offer interesting possibilities to vocational task learning, because they are often based on a set of authentic working-life tasks and competencies built step by step, where different professionals have to engage in teamwork.

An interesting overlap between learning and virtual games is the interaction between the players. It is typical of good collaborative computer games that players find others tempting and want to play with them (Manninen, 2004). Through discussions, collaboration, and reflection on the game events the players learn how to play. At the same time they learn important collaboration processes such as negotiation and coordination (Williamson & Facer, 2003). Other benefits of such games include a higher degree of immersion and interactivity – digital games are created in essence to engage all players in active participation (Charles & McAlister, 2004).

According to the latest research, educational games can, at their best, improve the outcomes of learning (Lyytinen et al., 2005). Although educational games have traditionally been drill-and-practice type of games, more sophisticated and creative applications of new technological solutions are needed. It is therefore necessary to explore the added values and limitations of educational games featuring new technological solutions. When scripting and implementing “edugames”, it is important to heed the lessons learned in entertainment games and make use of the potential of story telling and strategic games. For example, the narrative of a digital game is not independent from the construction of the game levels and characters (Charles, 2003).

4. Aims

This study attempts to combine the technological possibilities of game environments and the theoretical knowledge of CSCL. The Mustakarhu study is a part of the ECOL (Ecology of Collaboration) research project (which examines collaborative learning as a motivated and coordinated activity) and also a part of a larger
project, PEDAGAMES, which investigates the possibilities and limits of pedagogical games in vocational education. The present study involves a design experiment, which comprises the design process of the Mustakarhu game environment, description of the script developed for this game, as well as the empirical study with multiple data collection methods, data analysis, results and conclusions for further work (Bannan-Ritland, 2003; Collins, Joseph, & Bielaczyc, 2004). The development of the game and the related empirical study was a joint effort between three parties.

There were two research tasks in this study. The first research task was to develop a game environment to simulate the work context of the vocational design process of surface treatment and to describe the game and design process by means of scripted tasks. The second research task was to answer the following questions on the basis of empirical study: (1) How did the game environment influence learning processes? (2) How did scripting affect players’ actions and what kind of collaboration did take place during the gameplay? (3) How did groups vary in their activities despite the scripted environment?

5. Instructional design of Mustakarhu game

In this study an attempt was made to develop a new virtual space for collaboration and vocational task learning (Dillenbourg, 1999; Dourish, 1999; Munro, Höök, & Benyon, 1999). In vocational learning the need for both collaborative and cooperative processes is based on authentic problems of working life, and the design of the game thus followed the relevant curriculum. The design draws on the features of illustrative environment provided by the virtual game. It was recognised in the game development that it would not be reasonable to merely transfer learning from a classroom setting into a virtual environment (Arvaja, 2005). The game environment was expected to offer learners some added value. The use of online simulations and educational games, in particular, is justified by catering for such aspects of the curriculum and learning tasks that have traditionally been difficult to teach or demonstrate in the classroom (Charles & McAlister, 2004).

The leading idea in the game design was to simulate the work context of a vocational design process, which involves a vocational task to design four different customised hotel rooms. The philosophy behind the game design is to offer the kind of gameplay in a virtual environment that allows such practice that would otherwise be almost impossible, or at least very costly to arrange. Mustakarhu is a virtual 2D/3D online game for four players, and it aims at epistemic task-solving. The game environment was based on the idea of collaborative learning. The aim was to use scripts and different game levels in a way that supports pedagogical goals. Epistemic collaboration scripts (Weinberger, 2003) with some social modes were applied to make learning more efficacious. The teacher has an active role in after-game reflection, but does not intervene during the actual play. Teachers’ expertise played a central role in the design of the background setting for the game. Due to the limited duration of the experiment, the content of the game caters for approximately 45 min of goal-oriented activities. Role management and player-to-player communication are supported by chat or voice-over-IP speech systems, which allow free dialogue between the players.

5.1. Mustakarhu script

The scripts were designed to encourage students to make decisions together. The game includes three different types of puzzles; some can be solved individually, but others require effort and commitment from the whole team for successful completion. Hence, different modes of collaboration and cooperation are required. During the game students are expected to design the rooms, calculate the areas and costs of the materials (within a team budget of 4000 euros), answer a quiz about materials, and finally write a report about the design process. Table 1 gives some specifications and background information on the game (name of the script, objectives, target audience, range of application, context, locus of representation, granularity, coercion degree, duration, environment and design principle).

The game comprises epistemic tasks of design and surface treatment of hotel rooms, which entails learning and practice of collaborative learning mechanisms. The game includes 13 sets of vocationally oriented problems, of which six are mathematical problems. The second part of the script description consists of a storyboard with information on expected collaboration (Table 2). As the following table shows, the game
integrates individual work to collaboration (e.g., in Phase 6); the costs of floor materials for each room need to be calculated and the sum affects the joint team budget. The extent of expected group processes varies during the gameplay.

Table 2
Storyboard with expected activity outlines

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Form a team of 2-4 members – for designing customised hotel rooms</td>
</tr>
<tr>
<td>2</td>
<td>Choose a room for each player (collaboration)</td>
</tr>
<tr>
<td>3</td>
<td>Negotiate the rules for the game – you have a team budget of 4000 euros (collaboration)</td>
</tr>
<tr>
<td>4</td>
<td>Calculate the area of the floor (individual or collaboration)</td>
</tr>
<tr>
<td>5</td>
<td>Choose the materials for the floor (collaboration)</td>
</tr>
<tr>
<td>6</td>
<td>Calculate the costs of the floors (individual or collaboration)</td>
</tr>
<tr>
<td>7</td>
<td>Calculate the area of the walls (individual or collaboration)</td>
</tr>
<tr>
<td>8</td>
<td>Choose the materials for the walls (collaboration)</td>
</tr>
<tr>
<td>9</td>
<td>Calculate the costs of the walls (individual or collaboration)</td>
</tr>
<tr>
<td>10</td>
<td>Calculate the area of the ceiling (individual or collaboration)</td>
</tr>
<tr>
<td>11</td>
<td>Choose the materials for the ceiling (collaboration)</td>
</tr>
<tr>
<td>12</td>
<td>Calculate the costs of the ceiling (individual or collaboration)</td>
</tr>
<tr>
<td>13</td>
<td>Quiz of the materials (individual or collaboration)</td>
</tr>
<tr>
<td>14</td>
<td>Write a final report for the customer (collaboration)</td>
</tr>
<tr>
<td>15</td>
<td>Reflection situation with teacher and/or researcher</td>
</tr>
</tbody>
</table>
6. Methods

6.1. Data collection

This study includes the design of the game and an empirical experiment conducted in authentic educational settings. The experiment was organised among mixed groups (male and female students from different courses) of vocational students \((N = 20)\) divided into five groups of four persons. A specific laboratory environment was constructed in the institute of vocational learning in order to capture all the required data from the experimental game sessions. During the experiment the students played the game session at the same time and had a stimulated recall interview immediately after the game. Data were gathered by various means such as videotaping each group, audio recording their discussions and/or logging chat conversations and player activities during the game. Other sources of information included observation notes and stimulated recall interviews. (In the interviews the students, the teacher and/or the researcher indicated meaningful situations within the play, which were then analysed together, discussing what had happened there and why.) Moreover, there were the final plans produced in the game (scoring was based on the combination of reasoning the final choices of the materials, staying within the budget and considering different aspects from the viewpoint of the customer’s order) (Table 3).

6.2. Data analysis

The data analysis was partly theory-driven (Berger & Calabrese, 1975; King, 1999; Webb, 1989) and partly data-driven. After the game experiment, all the data were verified, interviews and conversations during gameplay were transcribed, observation notes were sorted into relevant categories and evaluations of the final plans were conducted. A qualitative analysis across the whole variety of data was carried out using data classifications. The first classification was based on the key points scripted into the game environment and the expected interaction processes. At this stage the teams were analysed in terms of the collaboration processes or teamwork they achieved during the play. Collaborative groups used, for example, elaborative questioning, made sure that all team members were able to go along and negotiated more than groups which preferred teamwork and simply used communication to go through the tasks. In the second classification, the groups were examined in more detail level to find out what kind of individual activities the players used to solve problems and how important these were for gameplay. Within these first two stages cross-summarisations between the groups were also conducted to find out group-based differences occurring despite the scripted environment. And finally, the analysis focused on how the environmental elements affected collaboration. Cross-comparisons of sets of research materials collected by various methods were performed to improve the reliability of the research results (Cohen, Manion, & Morrison, 2001).

7. Results

7.1. Added value of the game environment

Afterwards all the students felt that the game environment had offered added value by visual outlining, as compared to the traditional classroom setting. Related data analysis indicated that the design process was also considered more motivating this way than the traditional pencil-and-paper method. A new form of interaction

<table>
<thead>
<tr>
<th>Data-gathering process</th>
<th>Videotaping each group (+chat conversations)</th>
<th>Combined 4-players game process</th>
<th>Stimulated recall interview</th>
<th>Players’ activity logs</th>
<th>Final outcome of the play</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data-process stage I</td>
<td>Transcribing the conversations (after the game)</td>
<td>Taking observation notes (during the game)</td>
<td>Transcribing the interviews (after the game)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
emerged during the game, as all players used some “visual communication”. They spent long periods of time comparing different materials. During that time they did not speak or write, but they were highly concentrated on browsing through different options for materials until they found good ones. The students found this new learning environment as a positive experience, and especially they appreciated the illustrative presentation of materials. According to student’ opinions and observation notes, another advantage of the virtual environment was that it made it easy to experiment with different materials and the students could immediately see the actual results of their choices. In the game they used the illustrative 3D model to view the rooms from different angles. In analysing the data, it turned out, however, that besides this illustration point of view, some players used the model as a chance to take a break when the cognitive load started to build up too much.

According to log data, videos and observation notes, playing was intensive in each group. The players found the authentic tasks challenging. Especially students with some work experience were excited about finding similarities and differences between the real and virtual worlds. The players felt safe in the virtual environment, and observation notes confirmed this subjective finding. On a more general level, some of the players found that the gameplay was somehow like playing for fun. For future educational games, students suggested more challenging tasks, such as determining the thickness of paints, and also the possibility to return to the tasks afterwards to make changes.

7.2. Game process in scripted key points of the game

All five groups followed the scripted task order and completed the game successfully. So the script guaranteed that all teams were able to go through the game. The scripted game environment enriched task learning by enabling aspects that would not have been possible in traditional classroom settings, such as immediate visual comparison of materials as well as their respective expenses. In Phases 1 and 2 all groups resorted to cooperation to get to the next level. However, the analysis of subsequent data revealed that the students’ game processes varied a great deal despite the scripted environment. Biggest differences between the groups emerged in their use of individual working, teamwork and collaboration as shown in Table 4 below. Collaboration is distinguished from teamwork so that in collaboration learners were more active in discussions and engaged in higher-level discussion. Such engagement showed, for example, in elaborative questioning, explaining and reasoning.

Cooperation took place on an equal basis and data analysis indicated that the game essentially guided the team members to make sure that everybody was able to go on. The players felt that peer support during the game was important and they did not want teacher’s guidance at that time. The players appreciated each other’s presence and possibilities to ask for help. After the game the students reported that they had been able to help each other, and observation notes and log data confirmed this finding. Conflict situations during the game were rare and the groups solved the problems in mutual understanding. There were no cognitive

| Table 4 |
|---|---|---|---|---|
| **Story** | **Group 1** | **Group 2** | **Group 3** | **Group 4** | **Group 5** |
| Phase 1 | Cooperation – all groups | | | | |
| Phase 2 | Cooperation – all groups | | | | |
| Phase 3 | Collaboration | Collaboration | Teamwork | Collaboration | Collaboration |
| Phase 4 | Collaboration | Individual | Teamwork/individual | Collaboration | Individual |
| Phase 5 | Collaboration | Collaboration | Teamwork | Collaboration | Collaboration |
| Phase 6 | Collaboration | Collaboration | Teamwork/individual | Collaboration | Individual |
| Phase 7 | Collaboration | Collaboration | Teamwork/individual | Collaboration | Individual |
| Phase 8 | Collaboration | Collaboration | Teamwork | Collaboration | Collaboration |
| Phase 9 | Collaboration | Collaboration | Teamwork/individual | Collaboration | Individual |
| Phase 10 | Collaboration | Collaboration | Teamwork/individual | Collaboration | Individual |
| Phase 11 | Collaboration | Collaboration | Teamwork | Collaboration | Collaboration |
| Phase 12 | Collaboration | Collaboration | Teamwork/individual | Collaboration | Individual |
| Phase 13 | Collaboration | Collaboration | Teamwork/individual | Collaboration | Individual |
| Phase 14 | Collaboration | Collaboration | Teamwork | Collaboration | Collaboration |
conflicts, but the time spent on the choice of materials, for example, could become an issue with some of the groups.

During the game, students used different methods to achieve and maintain collaboration. Scripting guided the team members towards shared problem solving. The game encouraged players in all groups to try various types of negotiation (especially in calculation tasks). As can be seen in the following excerpt, players negotiated not only about the actual tasks and problem solving but also about the game functions.

Minna: everybody OK if I take this laminate?
Anna: yeah, go ahead, Minttu [a nickname]
Minna: :)
Eve: suits me, I’ll take the tiles.
Henna:
Anna: jeez, what’s this linoleum?????
Eve: dunno.
Anna: can I take that plastic covering?
Henna: hey come on, where on earth did you guys find that material point..!!!
Anna: well where are you now then, Henna?
Henna: this is just a mess!!
Eve: on the previous page there was some continue box, click on that
Anna: calculate that area that how many square meters there are and click the calculate button.

7.3. Differences between the groups

The groups differed in terms of the outcomes of the design process, the time spent on the game (from 27 to 55 min), the level of interaction and amount of collaboration shown. As far as the results are concerned, all five groups came up with a reasonable and feasible plan for four different hotel rooms. The plan by Group 3 was not as good (three points out of five) as the other groups’ plans, however. (Scoring was based on the combination of reasoning the final choices of the materials, staying within the budget and considering different aspects from the viewpoint of the customer’s order.) Biggest differences between the groups were found in their respective levels of interaction. Table 5 below lists typical features of each group. Next we will take a closer look at the special characteristics of each group’s interaction patterns in the scripted environment.

Group 1 used collaborative working processes throughout the game and went on task by task together as a team. Log data and observation notes confirmed that the completion times for the different phases varied only

<table>
<thead>
<tr>
<th>Typical features of the groups</th>
<th>Score for final plan</th>
<th>Time spent on the game</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong> Collaboration</td>
<td>Kept track of each other – reflection on own experiences</td>
<td>Completion times for the different phases varied only a little</td>
</tr>
<tr>
<td><strong>Group 2</strong> Individual working changed to collaboration in Phase 5</td>
<td>Amount of elaboration grows during the work</td>
<td>Plenty of “visual communication”</td>
</tr>
<tr>
<td><strong>Group 3</strong> Teamwork – did not reach real levels of collaboration</td>
<td>Level of cognitive activities low and little time used in interaction</td>
<td>Low level solutions</td>
</tr>
<tr>
<td><strong>Group 4</strong> Collaboration Inexperienced players – need for each other</td>
<td>Plenty of negotiation, elaboration, humour and positive feedback</td>
<td>Completion times for the phases were equal</td>
</tr>
<tr>
<td><strong>Group 5</strong> Individual + collaboration alternates – despite individual orientation the team was able to reach collaboration</td>
<td>3 of 4 members prefer individual working</td>
<td>The completion times in individual phases varied</td>
</tr>
</tbody>
</table>
a little in this team. This group kept track of each other both by spoken dialogues and by visual communication and they also made sure that all members understood each other. They used a lot of questioning, but mostly at a very practical level. This team did not spend much time on planning, but elaborated and modified their plan as the work progressed. Within this team one of the members took a very active role in keeping track that all tasks were completed and answered properly as shown in the following excerpt.

_Hille: did you put in something about the prices??_

_Hanna: what did you select there for the ceiling material there_

Anni: the old paint surface

_Hille: I think I had concrete...

_Hanna: pietiläinen [a name] repeats.....

Helena: plastering, I guess

_Hille: C’mon guys, did you give any grounds for those prices??_

In Group 2, the players started the game working individually so that their completion times for the first mathematical problem (Phase 4) showed a range of over 6 min. After this, however, the group realised that collaboration paid off in all these problems and accordingly resorted to this strategy through the rest of the game. So the difference in their completion times in Phase 5, for example, was about 2 min as shown in Table 6 below. The time spent on each phase increased after Phase 5, while the group started to use more elaborative questioning and negotiation, which led to a higher level of interaction. This group used, especially, plenty of visual communication when it came to the choice of materials. For this group, using more time on collaborative processes eventually also paid off as regards the quality of the learning outcome. After Phase 5 this group reached a good collaboration in their work and their final plan for the hotel rooms was also of high quality.

Group 3 went for teamwork, but never reached collaboration. Also this group took advantage of the virtual game environment in terms of visual outlining, but from the viewpoint of collaborative learning they did not reach the goal set for the gameplay. The level of cognitive activities was lower than in other groups; the students seldom negotiated but went for the simplest possible solutions (as can be seen in the excerpt below in which the learner gives a simple answer for material selection without elaboration or reasoning). For example, the team members gave straightforward answers to each other but did not make any elaborative questions. Their level of commitment was low, which showed, for instance, in that their answers to other members’ questions often remained “hanging in the air” in the manner of “it’s just the way things are”.

“Reasons for material selection: The sole reason for material selection was colours.”

The Group 4 players were inexperienced and quite dependent on each other. They made sure that all members were able to solve problems, shared information, and everyone took part in all kinds of activities. This group used a lot of humour in solving tasks during the game. They also had a lot of interaction and their completion times for the phases were equal. During the game one of the players in this group stated that in her opinion the game environment was not a good way to study. Afterwards in the interview she also said that she would have preferred traditional methods. As regards this learner, the results indicate that good collaboration and learning outcomes can be reached despite a negative attitude towards the learning environment itself.

Group 5 resorted to individual working as much as possible. Within this group, the completion times for individual phases varied up to 15 min. In the stimulated recall interview three of the group members told that

<table>
<thead>
<tr>
<th>Phase 4 – calculate the area of the floor (individual or collaboration)</th>
<th>659: 2004-03-29 11:43:26</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teppo calculated the area of the floor</td>
</tr>
<tr>
<td></td>
<td>Sini calculated the area of the floor</td>
</tr>
<tr>
<td></td>
<td>Henna-Riikka calculated the area of the floor</td>
</tr>
<tr>
<td></td>
<td>Kari calculated the area of the floor</td>
</tr>
<tr>
<td>Phase 5 – choose the materials for the floor (collaboration)</td>
<td>664: 2004-03-29 11:53:22</td>
</tr>
<tr>
<td></td>
<td>Teppo chose the materials for the floor</td>
</tr>
<tr>
<td></td>
<td>Kari chose the materials for the floor</td>
</tr>
<tr>
<td></td>
<td>Sini chose the materials for the floor</td>
</tr>
<tr>
<td></td>
<td>Henna-Riikka chose the materials for the floor</td>
</tr>
</tbody>
</table>
they preferred individual working methods compared to collaborative ones. Within this group only the tasks (material choices) that forced the team to work together made them ask questions and use visual communication. Interestingly, when collaboration was needed this group was able to negotiate, make elaborative questions, listen to each other and build a task solution together. These students had experience from authentic work-life situations. They found the experiment easy and felt that they would have benefited from more complicated tasks within the game.

8. Discussion

This study indicates that, at their best, epistemic scripts have potential to make learning more efficacious in virtual game environments. However, when considering the findings, all limitations of the case-study approach should be kept in mind. Within this study the scripted environment helped ensure that all players were able to go through the game. Their learning outcomes also indicated that epistemic scripts can be used in a game environment to support learning for some students at least. Different levels of the game enable motivating scripts and it is also possible to integrate individual and collaborative learning with the game story. Within this study, for instance, there were great variations between the groups despite the scripted environment. Hence, the question arises how to make all teams collaborate as needed and how to increase the cognitive level of group activities, without over-scripting learning? Too strict scripting leaves no space for students’ own constructions and prevents them from using their full capacity for collaborative learning (Dillenbourg, 2002; Hämäläinen et al., 2005a). In addition, this study revealed that educational games should allow some rest or easing up the learner’s cognitive load between tasks.

In the light of this study a major benefit of the virtual environment was the possibility to visualise the design process in a manner that would have been impossible in a traditional classroom setting. The game process also brought up a new form of interaction, as the students were able to use visual communication, as well. The findings indicated that this game environment also offered a setting for different modes of interactions and encouraged teams to collaboration. Yet, collaboration was dependent on the learners’ willingness to work together, so that in one team (i.e., Group 5), whose members preferred working alone, collaboration took place only when absolutely necessary. Although this group also indicated that a scripted game environment may also help more individually oriented learners to engage in more collaborative activities. On the other hand, the learning results (as regards new knowledge construction and reasoning the final plan) of this group were excellent, despite they collaborated only when necessary. This brings up an interesting issue about the goals of collaboration: Should learning collaborative working methods be a goal itself or should the focus be on improved learning outcomes in vocational education? We can conclude, at least, that collaboration in itself should not be considered an intrinsic value in all situations and both individual and collaborative approaches are needed in the future in the area of learning games.

According to our findings, at their best edugames may enrich learning and the pedagogical use of technology. Although integrating learning and games provides tempting possibilities, it also poses many challenges. For instance, in this study groups with more collaborative working methods used more time in the game process and reached higher quality of the final plan. This contradicts the typical feature of many games that players get reward for speed. This poses a challenge to future educational games: How to combine the speeded and sometimes competitive elements of games with reflective learning and working together. In the future more edugames and experiments are needed so as to determine their possibilities and limitations in this respect.

In future learning activities the benefits of new technologies should be utilised more extensively. When discussing learning and computer games we should take into account the theoretical knowledge and needs of learning as well as the existing possibilities of game development. In other words, designing pedagogically meaningful virtual environments for specific contexts is a challenging task that calls for close cooperation between the technical game developers and specialists with pedagogic and field-specific expertise (from both teachers’ and learners’ point of view). Such design teams can take into account the needs of learning, possibilities of technical applications, and latest research findings. Especially in vocational education where learning is based on authentic tasks, better ways to visualise such learning tasks are needed to address motivational challenges. Edugames have potential in this respect. Illustrative presentation of occupational situations
through game-like applications seems to be one potential way to improve vocational learning and to respond to the changing needs of working life.

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