Designing Puzzles for Collaborative Gaming Experience – CASE: eScape

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ABSTRACT
This paper examines the issues of puzzle design in the context of collaborative gaming. The qualitative research approach involves both the conceptual analysis of key terminology and a case study of a collaborative game called eScape. The case 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. The findings and conclusions emerging from the analysis provide insight into the area of multiplayer puzzle design. The analysis and reflections answer questions on how to create meaningful puzzles requiring collaboration and how far game developers can go with collaboration design. The multiplayer puzzle design introduces a new challenge for game designers. Group dynamics, social roles and an increased level of interaction require changes in the traditional conceptual understanding of a single-player puzzle.

Keywords
Team game, multiplayer puzzles, computer-supported collaborative play, group dynamics, problem solving

TOWARDS MULTIPLAYER PUZZLE DESIGN
Digital games are essentially about fun and entertainment, and the pursuit of individual challenges. With the increasing number of games-literate people, society is slowly learning to harness games for more than merely mainstream market exploitation. Game design is moving into unexplored territories.

Nevertheless, a quick look at a cross-section of contemporary commercial games would seem to indicate the lack of diversity in the type and forms of gameplay. The market is overflowing with competitive and destructive games, which encourage individualism. Purposefully designed games that require collaboration are few and far apart in the world of digital games.

This paper examines the issues of puzzle and challenge design [17] in the context of

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collaborative gaming. The relevant questions are, for instance, ‘How does one create meaningful puzzles requiring collaboration?’, ‘Is there life beyond trial and error?’, and 'How far can game developers go with collaboration design?’. These questions, amongst others, are approached from the game design viewpoint, for the benefit of multiplayer game designers, players and researchers.

The focus of this study is on the design of multiplayer puzzles. These puzzles can be seen as game components that provide part of the challenge value for the players [5]. Traditionally, puzzles are considered as single player activities. Luban [10] categorises puzzle types into investigation, movement and goal puzzles, but mainly in the context of a single player. Kim [9], furthermore, outlines eight categories for multiplayer puzzles. However, of these, only avatar-based multiplayer puzzles are of relevance in the context of this paper. These puzzles require the presence of several avatars in order to simultaneously activate devices in different locations. The main challenge in such puzzles is social: persuading people to co-operate and co-ordinating their actions.

The nature of collaborative puzzles may prove to be different from traditional single-player versions since the aspect of interpersonal interaction can induce some changes in the puzzle setup. Nevertheless, the concepts of puzzle, conflict, competition and collaboration are all strongly bound together [19] and, therefore, the practical implications require further delineation. In addition, as described by Luban [10], there is a shortage of literature providing design implications for puzzle designers. The aim of this study, thus, is to shed light onto the complexities of collaborative puzzle solving.

This paper illustrates a case study of an experimental game design, eScape [6], which was constructed as a total conversion modification for Unreal Tournament 2003 [21]. In order to harness the potential of multi-disciplinary expertise, the designing of eScape was achieved by collaboration between the University of Oulu (LudoCraft Game Design and Research Unit and the Educational Technology Research Unit) and the University of Jyväskylä (Institute for Educational Research). Educational experts provided the designers with a set of pedagogical concepts guiding group collaboration support.

This research project was a design experiment, involving both the process of designing a game environment and an empirical study, where data was collected using multiple methods. The findings and conclusions emerging from the analysis provide an insight into the area of puzzle design and collaborative games.

COLLABORATIVE PLAY

The importance of supporting collaborative activities through virtual environments has been studied in the context of Computer Supported Cooperative Work (CSCW) [4]. According to Johnson and Leigh [8], one of the advantages of working in an immersive environment is the ability to have geographically distributed participants sharing space with each other and the objects under discussion. This makes it possible to have a common place for joint activities. To enable interactive experiences, the actions of the participants are mediated by user interface devices, computers and networks inside and outside the virtual environment.

Naturally, the aforementioned implications can be transferred into the context of collaborative playing. According to Baker et al. [3], games do not just entail having participants in virtual surroundings. Instead, they offer meaningful and motivated actions for the players, which, in turn, enhance the potential for collaboration. The shift from the work context into the context of play and games has encouraged the researchers to conceptualise the phenomenon accordingly. Wadley et al. [22] define Computer Supported Cooperative Play (CSCP) as mutual engagement by two or more individuals in recreational activity mediated by a computing environment. While some CSCP activities appear competitive, the co-operative play context also entails individuals pursuing conflicting goals, i.e., players can co-operate even when competing against each other.

The co-operation aspect is somewhat clearer in the context of team play. Playing together as a team generally means that people collaborate in order to achieve something they all agree is worth achieving. According to Sinclair [20], collaboration is the act of working together to produce a piece of work, especially a book or some research. In the context of this study, collaboration can be further defined as a joint activity conducted by a group of players in order to actively pursue a common goal.

Since many players thrive on, and long for, the challenges games provide, and are enriched by the learning that follows [18], the collaboration should involve goals in the form of perceived game-like challenges. In order to have the element of play intrinsically embedded in the activity, the easy achievement of this goal has to be prevented by a series of obstacles [7]. If these obstacles are passive or static, the challenges faced by the players can be defined as puzzles. These puzzles, then, create conflict, which arises naturally from the interaction in a game [5].

Collaborative play, therefore, does not necessarily involve contest amongst adversaries. It is more like the players co-operate to achieve a common goal against an obstructing force or natural situation that is not really a player [1]. However, even in the most seamless team play, there is always the potential for conflict between the participants. Different strategies, varying levels of motivation and contradicting visions can all create ground for conflict. Furthermore, Salen & Zimmerman [19] state that all games are competitive by nature. Players struggle against each other or against a game system as they play. Without this sense of competition, meaningful play would be difficult, as players would not be able to judge their progress through the space of possibility of a game.

Collaborative play, in spite of its commonness in the domain of traditional play and games, is not easy to support in the context of computer games. In particular, the form of group collaboration defined as player cooperation [19] would seem to be a less implemented area in games. The main exceptions, however, are two-player co-operative arcade games, such as Alien Syndrome [2], and action games with additional co-operative missions, such as Project Eden [16] and Operation Flashpoint [14]. Still, if we leave aside the traditional team-based conflict scenarios, and focus on puzzle-orientation and non-personal competition, the challenges for design and implementation rise dramatically.

Supporting collaborative play in multiplayer computer games can be implemented in various

areas of game design. On the low, mechanical level, games should support small-scale actions and interactions, such as voice communication, gestures, awareness of others and shared access to resources, which enable players to do tasks in a collaborative fashion [15]. In game design, these can be mapped to low level interaction mechanisms, which define what players can do in the game and how the game responds to their actions [12].

The aforementioned concepts, models and practices will be further analysed, grounding the work on an earlier research case, *TeamGame* [11], in the light of an experimental game design case. The following section describes the design and implementation of eScape - a collaborative puzzle game experiment.

GAME DESIGN EXPERIMENT - ESCAPE

eScape is a four-player collaborative game, which can be defined as a social action-adventure game targeted at novice players. The high concept of the game is an escape story, in which a group of players has to solve a set of problems - or puzzles - in order to flee from an ancient prison colony. The puzzles are designed so that each participant's effort, commitment and action are required for a successful outcome. The game provides each player with a first-person-view into the 3D game world. Players are interconnected via a game server, which runs the virtual world in which all the actions occur. The player interface consists of a PC with standard peripherals. Figure 1 illustrates the game master's view into the game world.

Figure 1. Players ready to escape from the prison colony after solving a balloon building puzzle.

In addition to visual and non-verbal in-game interaction, player-to-player communication is supported by a voice-over-IP speech system, which allows free dialogue. Rich interaction is enabled for the players in as intuitive and non-intrusive a manner as possible. The choices, manoeuvres and other features are simple enough to be used by the non-gaming community.

Design and Implementation of eScape

In the design of eScape, the main focus was on constructing a game environment that would promote collaboration between team members and support the process of becoming a team. To

encourage collaborative activities, the game world consists of a small-scale thematic setting that channels and constrains the players' activities. The overall design criteria, in relation to the aforementioned literature, consist of four separate areas: place, collaboration, interaction support and puzzles. The design statement can be outlined as follows:

> eScape is a *virtual game world* for joint activities [4, 8] forming a 'third place' [22] for the player group to engage in collaborative play that can be seen as *player cooperation* [19]. The operations and actions of the players are supported by the game system on the *low level of interaction* [13, 15]. The *challenge* [17] is provided in the form of *obstacles* [7, 1], which are constructed as *puzzles* [5] designed for collaboration.

The pedagogical criteria for game design emphasise group dynamics. These criteria were set by the client during joint design sessions. The main collaboration processes to be supported by the features of the game included the following:

1. *Joint goal orientation* by defining common goals and committing to those.
2. *Negotiation* of possible solutions, strategies and action plans.
3. *Planning* of possible solutions and actions.
4. *Sharing information* between group members.
5. *Co-ordination* of different perspectives (and actors).
6. *Joint rule-making* on how to act (or not to act) in certain situations.

The design of eScape aimed at creating significant key points, i.e., puzzles, at which collaboration was expected to take place. The design was hidden from the players behind the game's escape story. Due to the limited duration of the experiment, the content of the game was designed to enable approximately 60 minutes of goal-oriented activities. The puzzles of eScape form mainly a linear sequence and they all need to be solved by the players in order to complete the game. The designed collaborative puzzles and the corresponding design criteria are described in Table 1, while the overall structural organisation, and the spatial layout of the puzzles within the game world, is illustrated in Figure 2.

Table 1. Brief descriptions of eScape puzzles.

Puzzle	**Description**	**Design Rationale and Criteria**
1. Prison Cells	Players start in isolation. Voice communication is enabled, but no visual contact between the players. Players need to pick up their tools near the door to start the predefined two-minute launch sequence.	Isolation period for focusing on the basics and for increasing the impact of group-forming. Criteria: negotiation, planning, sharing information, co-ordination.
2. Balloon Parts	Higher level puzzle, where the players need to collect four sets of balloon parts and bring them to the non-player character (NPC). NPC informs players on the current status.	Joins four puzzles together. Provides overall status information. Criteria: joint goal orientation, negotiation, planning, sharing information, joint rule-making.
3. Climbing	The platform needs to be accessed either by building steps from boxes, or by using a seesaw and launching one player	Different solutions, possibility to change puzzle sequence.

	on top of the platform.	Criteria: planning, sharing information, co-ordination.
4. Bees	Players collect bees' nests from the field. Entering the field requires the use of a protective barrel, which blocks the view. Other players guide the barrelled-one into the right direction.	Co-ordination essential. Criteria: planning, sharing information, co-ordination, joint rule-making.
5. Drums	Players need to guide a blind man off the pier by playing their drums in the correct order and at a correct pace.	Co-ordination with temporal challenge. Criteria: joint goal orientation, negotiation, planning, sharing information, co-ordination, joint rule-making.
6. Rocket Pattern	Players need to combine red and blue rockets, launch them in a correct, timed, sequence and form the required fireworks pattern.	Coordination with temporal challenge. Criteria: joint goal orientation, negotiation, sharing information, co-ordination, joint rule-making.
7. Balloon Building	After acquiring all four boxes, the players need to use their personal tools in synchronisation in order to keep the building process going.	Coordination with synchronisation challenge. Changed UI metaphor for increasing the difficulty. Criteria: joint goal orientation, negotiation, planning, sharing information, co-ordination, joint rule-making.
8. Balloon Lift-off	All players need to enter the balloon in order to start the escape sequence.	Requires definition of common goal and status. Criteria: joint goal orientation, negotiation, joint rule-making.

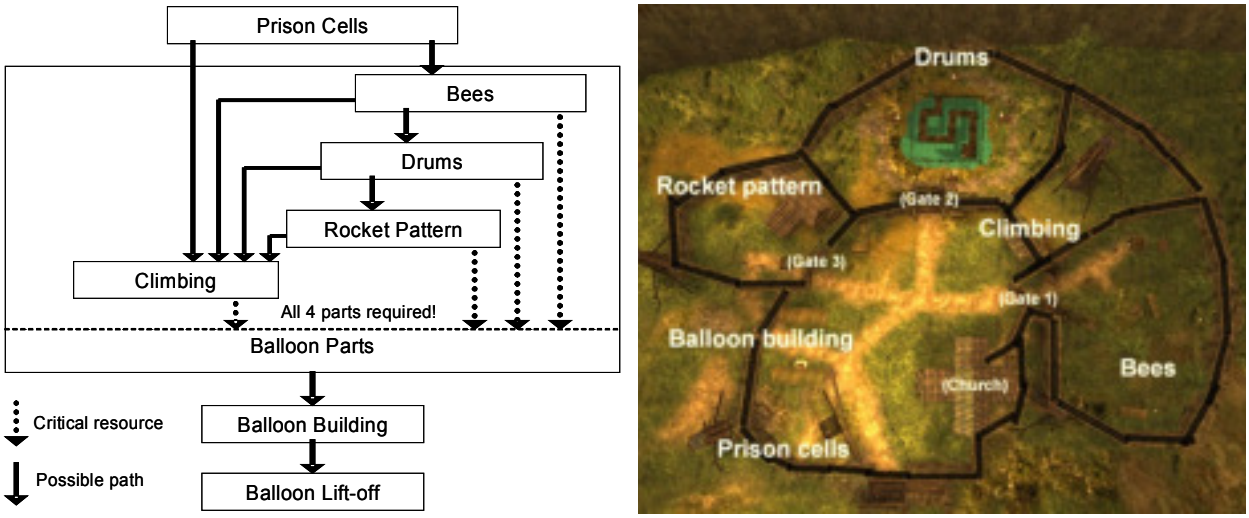

Figure 2. Logical and causal structure of the puzzles (left) and an aerial view of the eScape prison colony with the puzzle locations indicated (right).

Experiment Setup

A special laboratory environment was constructed to capture all the required data during the experimental game sessions (Figure 3). The multiplayer nature of eScape required extensive data collection arrangements since every player's actions had to be recorded. In order not to compromise the research setting, the players were physically isolated from each other. Cubicles were arranged so that the players were not disturbed from outside the game world. This made it possible to have numerous data recording devices and assistants within the set.

Figure 3. eScape laboratory environment with the operators, virtual camera screen and player cubicles (left), and players in action while the observers take notes alongside video-recorded data gathering (right).

Experiment Design and Data Collection

The eScape empirical experiment consisted of six groups of four test players chosen from the non-gaming community. On the first day, the players were given a brief training session through the game tutorial. 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 recordings of each of the players (over-the-shoulder view), combined views from all the four players (over-the-shoulder views as shown in Figure 4, left), video recordings from a virtual camera (in-game, Figure 4, right), audio recordings of spoken dialogue, demo recordings within the game platform (enables free virtual camera movements during playback) and stimulated recall interviews.

Figure 4. Four-player over-the-shoulder video recordings for synchronised data analysis (left), and an in-game virtual camera view (right).

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ANALYSIS AND REFLECTIONS

The analysis of player collaboration in puzzle solving was conducted by studying, in addition to the dialogue transcripts and interviews, the perceivable interaction forms [12] that were evident in the in-game video recordings. Based on this analysis, the implications for collaborative puzzle design were further evaluated in the light of the literature and against the design criteria.

Puzzles as Elements for Collaborative Actions

The seemingly dramatic opening puzzle (prison cells, no. 1) acted as an icebreaker for the newly formed groups. The isolation period at the beginning of the game, with no cognitive distractions, encouraged the players to start talking almost immediately. After release from the prison cells, the sudden encounter with other team members (thus far only audible via headsets) was clearly followed by enjoyable group forming.

After the initial grouping, the puzzles of eScape encouraged and enforced collaboration amongst players. This was clearly evident both in the video transcripts and subjects' interview records. However, the majority of the players reported the subjective level of collaboration to be much stronger than was observed in the video. Players did, indeed, talk to each other a lot while solving the puzzles, but some puzzles were solved by one- or two-player collaboration scenarios, instead of the whole group. For example, the climbing puzzle (no. 3) was solved by a single player in one group and, in other groups, only two or three players participated in the solving process. Also, during the bee puzzle (no. 4), only half of the groups solved the puzzle with all the other members actively participating. Nevertheless, the sense of team effort made players envision themselves as collaborators, although this was not always the case.

Despite the occasional spreading out of the group members, the puzzles seemed to keep the players relatively well within a particular region. Figure 5 illustrates the locations of the players during the three individual puzzles. In this sense, the most significant finding is the case of the rocket pattern puzzle (no. 6), which did not require strict spatial togetherness. Still, most of the players kept within close proximity to each other while shooting the fireworks.

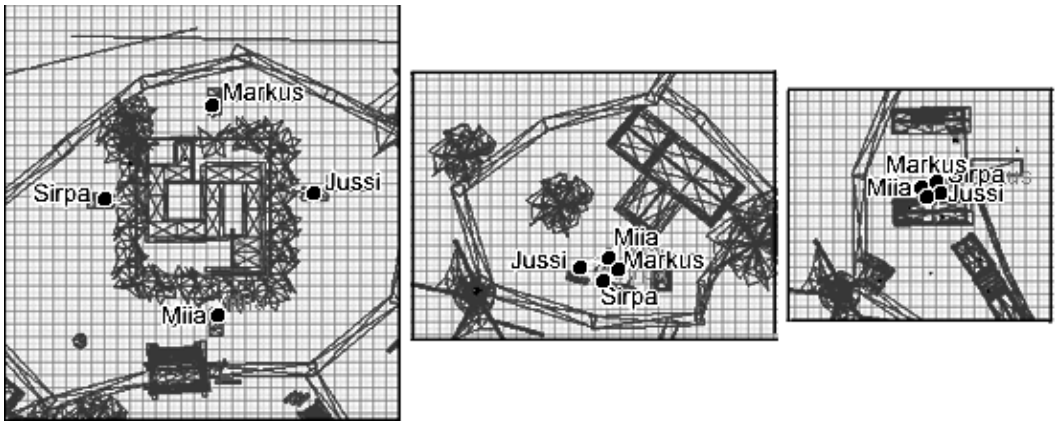

Figure 5. Locations of the players during the solving of puzzles. From left to right: drums puzzle (no. 5), rocket pattern puzzle (no. 6) and the balloon building puzzle (no. 7).

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No major problems were found when analysing the low-level interactions of player collaboration. With voice communication support, players were able to communicate without any significant effort. Some players were able to, or learned to, identify speakers from the sound of their voice, while others found it difficult occasionally. The following examples illustrate some of the problems with recognising other players. Eeva did not recognise Hanna, and Laura did not know who was by the fence:

> EEVA: You'll probably get it the same way. The page up, page down buttons. You'll get it in your inventory. Then you get the end...Who is running there?
> HANNA: I'm running. One gate is still closed. We should open it somehow. It has got something to do with this church. We have to get inside that church.

> LAURA: No, he probably opens that door. Now you there near the fence, press the button. Who is there? Is it Lilli?
> TANJA: Lilli is by the fence.
> LAURA: Wait I'll guide her all they way to this end.
> TARJA: Tell me if she is wearing a dress or something?
> LAURA: Yea, she is the one with a white dress.
> TANJA: Oh yeah, that's Lilli.

These indicate problems in the support for the awareness of other players. During the interviews, players stated that the identification name-tags (attached to the player characters) could not be seen when the players were far apart.

Player Roles, Co-ordination and Trial-and-Error Strategies

The perceivable player roles, in terms of co-ordination, changed distinctly with each puzzle. Overall, experienced players generally acted as leaders, but since the required skills varied according to the puzzle, leadership could change during the game. For example, in the case of the drums puzzle (no. 5), one of the players did not understand the solution and she was guided by group members who already grasped the workings of a puzzle:

> TOMASZ: Sanneke play.
> Silvia: Play please.
> SANNEKE: Yes.
> TOMASZ: And now me. Sanneke?
> SANNEKE: How do you play the drum?
> TOMASZ: Just to left the button.
> SANNEKE: What button?
> MATEUSZ: You have hands free(?) You make hands free first.
> SANNEKE: All right, Ok. And then I have to click. Yeah.
> TOMASZ: Ok.
> SANNEKE: Do we all play at the same time?
> MATEUSZ: No.
> SILVIA: No, now is my turn. (4)

An additional example of role-taking is the scouting. Most of the groups had one or two members who quietly, but efficiently, scouted the game world for hints, possible paths, and other valuable pieces of information. With introverted players, or an overly domineering leaders, the outcome of this kind of scouting was left unexploited by the group, which led to situations in

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which players 're-invented the wheel'.

In situations, which involved mainly trial-and-error puzzle-solving processes, co-ordination was perceived to be a problem. The chaotic single-player actions sometimes worked, but often failed. A mental challenge offered by the puzzles is clearly a desirable aim, but even if the potential (yet subjective) solutions of the puzzle are clear to the players before they start to work on it, the solving process itself usually involves trial-and-error [17]. The lack of innate tension in solving a puzzle, with corresponding reward and punishment structures [7], caused the dramatic element in the game to stay hidden. In the case of novice players, this places the game designers in a challenging situation, where they have to balance between the threat of punishment and the safe playing experience.

Perceived Obstacles and Emergent Conflict

Generally players were able to recognize the puzzles the first time they saw them. Two groups did not recognize the rocket puzzle immediately as a lock mechanism [17], which they needed to solve in order to progress in the game. Instead, they moved back to other areas to search for something new and interesting. After a while they returned to the rocket area, recognized the puzzle and started solving it:

> HANNA: What did that Ikuturso rises mean, hey?
> EEVA: Hey, it is probably linked to the phase when we have to build that balloon. And get it to fly.
> NIINA: We probably have to put these in this order somewhere, so that it leaves or something.
> EEVA: It's brown, blue, what was it? Brown, blue, blue, how did it go?
> JUKKA: But where do you put them?
> HANNA: Niina, we can't. After we have found it. Well, I tried and it shoots it away but that is the action. We can't put them in an order now. Let's find the next box and see what happens then.
> NIINA: We don't know how to do anything to these now.

In the aforementioned example, players have found the rockets and are discussing what to do next without finding the puzzle right in front of them. The puzzle design goes against the guidelines by Fullerton et al. [7], which states that puzzles should be integrated into the game-play and the story in order to be like interesting choices a player must make to progress in the game as a whole. This raises an interesting question of whether to make sure the players can easily find the puzzles, or whether to leave the puzzles ambiguous in order to increase the level of difficulty.

In any case, parallel to the easily perceived designed puzzles, the game sessions showed examples of emergent conflicts. This finding supports the notion by Fullerton et al. [7] stating that in the multiplayer mode you do not need puzzles to provide conflict, because the competition amongst players generates conflict. However, the observed conflicts did not originate from the competition. Instead, they seemed to resemble social phenomena caused by peer pressure and differing perspectives. For example, the concerns, and even strong comments, about wasting too many rockets in the rocket pattern puzzle (no. 6) becomes evident in the following data excerpts:

> ANNEMARIE: oh, I just don’t know

HILDUR: red blue blue red blue, ok, red blue blue [red blue
SIMON: you tried] one of them, you can shoot them?
HILDUR: Don't waste them (laughing)
SIMON: (Laugh) No, I won't

MERVI: Oh, what did you do?
JARI: I shot it.
PIA: Why did you shoot it?
JARI: I had to try it out.
ANU: You dumbass. Anyways, I have five of those. They are sort of in a row and there is an arrow going to the next one which goes to next one...

Some group members were very highly aware that there was a possibility of running out of rockets. They commented quite strongly to the other players when rockets where fired just for fun and without notifying others about it.

Breaking the Design Pattern

The balloon building puzzle (no. 7) introduced a completely new user interface mechanism for players. Some of the players were bored and others became frustrated when working on the solution. On the other hand, during this puzzle, groups tried many different ways to solve the problem with a trial-and-error process. In comparison to the other analysed puzzles, this one contained the most diverse solving strategies that were used. The following debriefing interview extract illustrates the general feelings of the players:

N: Oh, it was just nice that one had to look first.
M: Yes. It was not too easy and not too difficult. They could be more difficult next time.
N: I don't know if I would have guessed the button thing, if not then.
M2: I would probably have not, surely, no.
M: It was more like some kind of technical gimmick, detail. It is not part of the game really.
N: So, like I was also thinking exactly the same. It is not at all like the other things function in the game. The thing that you have to suddenly just keep it pressed down.
N : Yeah, press the button differently what you have been doing throughout the game.
N: One learned to use it in a certain way.
M: Maybe this amazingly difficult problem just to get us thinking about the possible solutions?
N: Exactly.

So, the players seemed to rationalise the mechanisms of the game, although some of them realised the puzzle was designed in a different way from the previous ones. Some sample tactics used by the players became evident from the following data excerpts:

ZDRAVKA: Probably everybody all together again
HILDUR: Okay, one, two,
ZDRAVKA: Yeah (laughing) two
HILDUR: And NOW
ZDRAVKA: Now?
HILDUR: So? (laughing)
SIMON: Yeah
HILDUR: Okay
ANNEMARIE: Okay, it´s one

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HILDUR: okay, it´s just not working, when I say now and I click it takes too long

The player group attempted to solve the balloon building puzzle by using items simultaneously, but failed to achieve complete synchronisation for their actions. When the expected solutions did not work, most groups started showing various degrees of frustration. While this generally indicates bad game design in terms of balancing, in the collaborative situation it would seem to heighten the sense of togetherness and levels of anticipation. The following excerpt shows both signs of frustration and an increasing sense of satisfaction:

SIMON: yeah, I think that´s what you have to do to get all four together
ZDRAVKA: Mhm, yes
SIMON: What?
ZDRAVKA: You what?
ANNEMARIE: The stupid same thing once again, all together
HILDUR: First I
ZDRAVKA: If it doesn´t work, then we try something else
SIMON: Yeah
HILDUR: We tried it ( ) three times already but alright, I´m pushing
ZDRAVKA: okay, just
SIMON: Oh
ZDRAVKA: You just ( ) Just keep pressing the button!
ANNEMARIE: yeah, I´m
HILDUR: And –Ouhh
ANNEMARIE: Yeah, okay, yes!

Furthermore, the groups tried a variety of seemingly potential but inefficient solutions while struggling with the balloon building puzzle. All in all, based on the results of the average solving times, this puzzle was the hardest one. The main difficulty would seem to have been caused by the anomalism in the interaction mechanism, which was not easily figured out by the players. However, since the puzzle was the second last in the series, the players were experienced and motivated to solve this one as well.

Concept of Puzzle from the Design Point-of-View

One of the main distinctions between the empirical analysis and literature is the definition and use of the term 'puzzle'. The analysed puzzles of eScape included features from all three groups in Luban's [10] puzzle categories. For example, the whole balloon part scheme can be seen as a series of goal puzzles, where each component advances the solving of the balloon parts puzzle (no. 2). Furthermore, only one of Kim's [9] multiplayer puzzle types is evident in the data. It would, therefore, seem that previous literature has little insight to offer in the context of collaborative puzzles. This indicates that there may be need for refinements, or new inventions, in terms of central puzzle concepts.

DISCUSSION AND IMPLICATIONS FOR DESIGN

The main challenge was the design of motivationally guided, logical and challenging puzzles that would require true collaboration. In order to avoid ending up with trivial activities, the theoretical and practical expertise of game design was utilised. However, the traditional single-player puzzle concept is not always applicable in the case of collaborative puzzles. For example,

the definition of puzzles being little or no interactive [5], was found to be somewhat inaccurate, since the puzzles of eScape entailed a high level of interaction due to the multiplayer aspect (i.e., static puzzles became dynamic because of the group of players interacting while solving).

The study revealed encouraging results on the possibility of designing puzzles for collaboration, although some dangers were also identified. The design produced relatively simplistic and secure puzzles, which enabled safe trial-and-error procedures. Groups did formulate low-level action plans, but no group used much time to devise their plans. A higher level of collaboration could be supported by increasing the pressure, risk levels and/or creativity in the design. When players acquire a tangible sense of beneficial, or purely enjoyable, collaboration, they will naturally engage such strategies.

During the game, the groups used different modes of interaction to solve the game problems. 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. All groups negotiated amongst themselves and co-ordinated their work to advance the game.

The players also had distinct roles, although many of them were clearly not 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.

Systemic enforcement of collaboration between players means that all group members are needed to solve a puzzle. The analysis shows that the drums puzzle (no. 5) and the balloon building puzzle (no. 7) both enforced collaboration in the strictest sense. The mechanics of these puzzles worked according to the design due to the hard-wired requirements (i.e., four drums to be played in synchronisation and four tools to be used simultaneously).

While most of the puzzles seemed to support the collaboration criteria set by the design, the meaningfulness of the puzzles is still ambiguous. Many of Luban's [9] puzzle design heuristics were directly applicable and, based on the analysis, none of them were dismissed. Furthermore, all the players managed to complete the game on time, and also reported to having had fun while doing so.

The main limitation of the eScape project, and one possible reason for the lack of higher level collaboration, was the seemingly straightforward puzzles. The trial-and-error procedures kept the players busy, but they were not necessarily collaborating while chaotically trying everything possible. However, the findings indicate that the participants found highly innovative ways in overcoming the obstacles – sometimes even exceeding the boundaries set by the designers. The only solution to prevent the trial-and-error procedures would be to increase the level of the threat of, and actual, punishment for failed attempts.

The most significant finding of the case was the overall design implication: it is much more

difficult to design constructive multiplayer games than the traditional destructive ones. This seems to be in line with earlier findings [13]. While game developers can go relatively far with collaboration design, the final decision should always be left to the player - especially in group collaboration scenarios, which increase the interaction possibilities exponentially.

CONCLUSIONS

In this paper, we analysed the conceptual aspects of conflict, puzzle, and collaboration in the context of multiplayer puzzle design. An experimental game - eScape - was demonstrated as an empirical part of the study. An analysis of collaborative game sessions was conducted, and the findings were examined in relation to the literature references.

The main challenges and guidelines for collaborative puzzle design were explicated in the analysis section and further refined in the discussion part. Although the nature of the case study prevents making wide generalisations, the results could be adapted to other design cases. The qualitative account, with reflections and data excerpts, is hoped to make the contribution more accessible.

Multiplayer puzzles need to encourage and enforce collaboration by balancing solo-efforts and teamwork. Even hard-wiring the puzzles to require actions from all group members is applicable, if the possible deadlocks can be prevented. However, it is hard to design challenging, rational and non-destructive puzzles that require concrete collaboration, while preventing all single-player solutions. Despite the predefined objectives, this was not fully achieved by all the puzzles in the design experiment.

Although pedagogical criteria for collaboration processes were supported by the game, it was clearly also necessary to have strong support for the low-level collaboration mechanics. For example, possibilities for spoken dialogue and avatar-based non-verbal communication are critical media for collaboration. However, even in the most communicative settings, trial-and-error procedures for puzzle-solving emerge constantly. If the threat of punishment is not applicable, and if the application domain is other than mainstream gaming, one option is to design highly difficult, and even frustrating, puzzles.

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