Proceedings of CASCON 2015

Hilton Suites Markham Conference Centre & Spa
November 2nd - 4th

SPONSORS:
CAS Research
IBM Canada Lab

EDITED BY:
Jordan Gould - IBM Canada Ltd.
Marin Litoiu - York University
Hanan Lutfiyya - University of Western Ontario

INNOVATION THAT MATTERS
CASCON
2015 November 2nd - 4th

CASCON 2015 Proceedings

Sponsored By

CAS Research

IBM Canada Software Lab

Edited By

Jordan Gould – IBM Canada Ltd.

Marin Litoiu – York University Canada

Hanan Lutfiyya - The University of Western Ontario, Canada

Hilton Suites Toronto/Markham Conference Centre & Spa, Markham, Ontario, Canada
November 2 – 4 2015

Table of Contents

Workshops of CASCON 2015

Data and Analytics

Cloud Computing

Next Generation Systems

About...

Author Index

The Effect of a Collaborative Game on Group Work

Maaz Nasir
Rockstar Games
586 Argus Rd
Oakville, ON
L6J 3J3
maaz.nasir@gmail.com

Kelly Lyons
University of Toronto
140 St. George. St.
Toronto, ON
M5S 3G6
kelly.lyons@utoronto.ca

Rock Leung
SAP
910 Mainland Street,
Vancouver, BC
V6B 1A9
rock.leung@sap.com

Anthea Bailie
Markham Public Library
3201 Bur Oak Ave
Markham, ON
L3B 0T2
abailie@markham.library.on.ca

Fred Whitmarsh
Markham Public Library
3201 Bur Oak Ave
Markham, ON
L3B 0T2
fwhitmarsh@markham.library.on.ca

ABSTRACT
As enterprises strive to transform themselves in the face of emerging technologies and challenges, there is an increasing reliance on group work and collaboration across disciplinary and organizational boundaries. Often this requires establishing ad-hoc workgroups that come together to address a new problem over a short period of time. In these cases, it is important that group members can work together effectively in a short amount of time. We are interested in understanding how computer-based "icebreaking" video games can help group members work together in real world collaborations. To do this, we identified icebreaking video game requirements based on the literature and ran an experiment with ad-hoc workgroups within an organization to assess the effect of playing an icebreaking video game before one of their collaborative work tasks. We compared groups that participated in the icebreaking video game prior to the work task with those that did not. We found that groups that played the icebreaking video game demonstrated increased collaboration in the subsequent work task.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces - Interaction styles.

General Terms
Management, Human Factors.

Keywords
Multiplayer games; collaboration; icebreaker; cooperative work; game design; teambuilding

1. INTRODUCTION
With widespread increase in the popularity of commercial video games over the last few decades and people spending more and more time playing them, there has been growing interest in the research community on video games and their use beyond simple leisure activities. Pearce [23] argues that games and play are 'not inherently unproductive' and, in fact, 'the boundaries between play and production, between work and leisure, are increasingly blurring.' [23, p. 18]. Recently, researchers have investigated video games in the context of computer supported cooperative work, recognizing the collaborative aspects of games as collective activities with specific objectives [21]. A considerable amount of literature has been devoted to understanding the use of games for education [13, 15, 25], in motivating people to do work [9, 20, 35], as icebreaking mechanisms to connect strangers in public locations [5, 37], and for encouraging collaborative behavior [1, 21, 28, 31].

We are interested in how the collaborative aspects of computer games can translate into real work situations. It is quite common in professional environments for ad-hoc work teams to be formed on the fly to work on specific tasks. In these situations, very little time is available to transition into an effective and cohesive team, especially when teams have not worked together in the past. We believe that video games have the potential to play a role in helping newly formed teams develop rapport quickly. Collaborative video games, in particular, encourage interaction and create situations where individuals must work together to problem solve and move forward. Our two main research contributions, as presented in this paper, are: 1) the identification of requirements for an icebreaking video game; and, 2) experimental verification of the effectiveness of using an icebreaking video game to promote collaboration in subsequent work through a study involving individuals in an actual organizational work setting.

The rest of this paper is organized as follows. We begin by discussing related work in video games and the study of their use beyond entertainment. We then present our research goal followed by a detailed discussion of the requirements for an icebreaking game and the design of our game, *Operation Sting*. Our experiment and methods are presented next followed by our data analysis, results and discussion. We conclude with suggestions for future work.

2. RELATED WORK
2.1 Collaboration in Virtual and Game Spaces
Collaboration, as defined by Roschelle et al. [29, p. 70], is the 'mutual engagement of participants in a coordinated effort to solve the problem together'. Dillenbourg et al. [10] suggest that collaboration necessitates the interdependence of group members as they share ideas and reach a conclusion. The collaborative aspect of games is the subject of past research [3, 21].

There exist several examples of game-like 3D virtual worlds that have been used to support collaboration [1, 4, 31]. While these are not games per-se, it is interesting to observe the use of 3D environments to support serious work in which participants are embodied as avatars. The primary motivation of these environments is to supplement the collaborative experience of geographically distributed groups that cannot easily hold face-to-face meetings.

Researchers have also been interested in studying collaboration within games themselves. The motivation here is to analyze player behavior in order to gain insight into the design of collaborative software, as well as the design of better multiplayer games themselves. In [31], a variety of different commercial multi-player games are analyzed in order to develop an exhaustive list of collaborative patterns, extending upon the work in [28]. Team dynamics and collaboration in massively multiplayer online role-playing games (MMORPGs) such as Dragon Nest and World of Warcraft have been the focus of past research [7, 19, 21]. Techniques to support collaborative gameplay among children with varying cognitive abilities and game expertise have been explored in [16]. As the literature suggests, video games are the subject of study as collaborative environments. We want to determine if participating in the collaborative aspect of video games can help enhance collaboration in subsequent work activities.

2.2 Collaboration and Teambuilding through Games

More directly relevant to findings in our own research is past work on the use of in-game collaboration to promote teambuilding. A laboratory investigation reported in [8] found that collaborating with another person during a game can help improve perception and likeability of the other person, even in situations where success is not achieved. Competition, on the other hand, was found to not have any such effects. This is relevant to our work because a report of likability after the playing a game may have an effect on subsequent collaboration. In [14] the use of team building games in 3D virtual environments is considered. Three games are presented (*Crossing The Ravine*, *Castle Builder* and *Tower of Babble*) that were designed with three desired characteristics: 1) everyone in the group must participate; 2) success is more difficult if the team fails to work together to arrive at the solution; and, 3) communication is critical to finding that solution. Similarly, in [17], the design of eight different short puzzle games aimed to encourage collaboration among students is discussed. In creating such games, cooperation, information sharing and joint goal orientation amongst players are considered to be important design criteria. A Fire Emergency Response (FER) training game with an emphasis on the human-centered aspects of such situations is presented in [34]. The game's focus is on coordination between different players and how players can effectively communicate in circumstances where no one player has a complete understanding of the entire situation. Research on the design of teambuilding games reported in these papers [14, 17, 34] have influenced the identification of icebreaking video game requirements for our research.

A study of particular relevance to our research examines the indirect effects of virtual teamwork in a game prior to subsequent collaborative activities [24]. Their study involves experimental verification and the research question being investigated is very similar to our own. Participants worked together (in groups of 3) on two different collaborative activities: 1) a problem solving task involving the completion of a 3D jigsaw puzzle; and 2) a creative ideation task given a fictional business scenario. Groups in the experimental condition first played the music mini game (similar in gameplay to popular titles such as *Rock Band* and *Guitar Hero*) from the commercial title *Rayman's Raving Rabids* before participating in the two collaborative activities, whereas those in the control condition did not. The study produced promising results which suggest that playing the video game first had a positive effect on group performance during the collaborative tasks. These collaborative tasks were defined as part of the experiment and the groups were asked to participate in a specific creative task. In our study, we worked with ad-hoc work groups assigned to participate in a task by their organization. We also used a pre-work icebreaking game specifically designed to encourage collaboration and satisfy constraints of the real-work environment. Thus, the main differences between the work in [24] and ours are that we make use of a prototype game with a greater emphasis on collaboration, and that the subsequent group activity for our experiment was an actual work task among professionals.

We build upon this past research combining team building and icebreaking objectives with video games. We extend the work in [14], [17] and [34] to identify design requirements for an icebreaking video game which promotes collaboration in ad-hoc work groups. In doing so, we synthesize methodologies from educational game design as well as the study of collaboration within existing commercial video games. Finally, we conduct an experiment to measure the effect of playing the icebreaking game on subsequent group collaboration in actual work settings on ad-hoc teams.

3. RESEARCH GOAL

The primary goal of this research is to evaluate the use of video games as group activities that can enhance subsequent group collaboration in real-work settings.

For this study, our focus was on the analysis of short (60-70 minute) collaborative face-to-face work meetings as opposed to more long-term work projects. We are interested in understanding the effect of playing a collaborative video game on ad-hoc teams accomplishing a specific task. As such, we required an icebreaking game that lasted around 20-30 minutes.

3.1 Icebreaking Game Requirements

While there exist many collaborative video games, we had three constraints for our experiment's icebreaking game based on the fact that it was being designed to be used in situations where ad-hoc teams in organizations come together to work on a specific team-based task.

<u>Constraint 1:</u> *Groups must be able to participate in the game for a short duration (20-30 minutes).*

The icebreaking video game cannot be too long compared to the actual task itself. There are many commercially available collaborative games [31] which are generally designed to serve as highly involved experiences. Their main objective is to bring the player into the game and keep them engaged for as long as possible. In contrast, a short icebreaking video game requires an experience where participants (team members) can immerse themselves into the game relatively quickly, accomplish a few well defined objectives, and wrap up the game in a relatively short timeframe.

<u>Constraint 2:</u> *The icebreaking game must accommodate individuals who rarely play video games.*

In order to function as an effective icebreaker in a real-world work setting, both experienced and inexperienced gamers should be able to enjoy the activity together when working as part of the same team.

Constraint 3: The icebreaking game must capture the collaborative aspects of real work teams.

Finally, the icebreaking video game should include several collaborative gameplay features to encourage participants to coordinate and work closely with one another in order to draw parallels to collaborative work activities.

Given these constraints, we identified the following nine parameters of multiplayer video games, which have been adapted from the work in [15] and [38].

Complexity (intricacy, objectives, variety of choices, player control over outcomes [15, 27, 33]) The icebreaking video game should incorporate a *moderate level of complexity* to mentally stimulate the participants for the subsequent work task, but not so much that the icebreaking video game becomes too time consuming.

User interface (both software and hardware): In an icebreaking video game, the *interface should be easy to use* so that people with varying levels of video game experience can quickly adapt to the game. Precise aiming and 3D navigation (as needed in FPS games such as Left4Dead) or prior knowledge of unit micromanagement techniques (as in Starcraft 2) should not be a prerequisite to participate in the game.

Difficulty (skill, precision required, likelihood of failure in carrying out a task [15, 27]): The icebreaking video game should be *moderately easy* so as to avoid frustration and allow steady team progress.

Subject Matter (context of the story (if any), themes used, general game content [15]): Although not a critical to the design of an icebreaking video game, having a game with a *theme that appeals* to a variety of people would be useful for encouraging everyone to participate.

Participation: One of the primary purposes of the icebreaking video game is to encourage people to actively contribute in the subsequent collaborative work task; therefore, we would like to enforce collaboration by encouraging *balanced participation.* Each participant in the icebreaking video game should play a critical part in the progress of their team and must make some minimum level of contribution.

Unique Roles: In many situations, individuals in real-life work teams (particularly those involved in decision making and planning) come from various educational and professional backgrounds and have different expertise and strengths that they bring to their team. In the icebreaking video game, we would like to incorporate this aspect of unique roles into the game itself and *have different players perform different, yet individually important functions* [25, 38].

Social Interaction: The icebreaking video game should *encourage social interaction* by creating the need for players to talk to one another in order to figure out how to overcome various obstacles and assist struggling teammates, as is desirable in real collaborative work. Verbal communication, in particular, is an appealing option for interaction as it does not limit the speed and quantity of casual interactions.

Collaborative patterns (complementary roles, synergies between player abilities, shared goals, limited group resources [31, 38]): The icebreaking video game should *incorporate a few of these basic patterns*. The icebreaking video game does not need to be a highly collaborative game but, it should encourage subsequent collaboration.

Synchronicity (simultaneity with which individual players participate in a game): Based on synchronicity, games can be classified into three distinct types: 1) Concurrent (same time in parallel), 2) Synchronous (same time taking turns), and 3) Asynchronous (different times) [38]. The icebreaking video game should *support concurrent play*, to ensure continuous engagement of each player in the same amount of time, allowing for shorter games that are still fun. In contrast to concurrent games, players playing a turn-based game may be more likely to be helped by others during their turn (since their teammate is idle during this time and willing to offer support). This may create a dependency on having other players make the decisions for them instead of thinking for themselves.

While we surveyed many existing commercial games, we were not able find one that met all of these requirements. Many fell short on having the ideal duration. Those games which did allow for short experiences were either too simple to give players the opportunity for sufficient collaboration or required pre-requisite knowledge and prior experience with similar gameplay. As such, we sought to create our own game, *Operation Sting*, to satisfy each of the requirements. Table 1 summarizes the constraints and requirements for the *Operation Sting* game.

Table 1. Game properties and icebreaking video game constraints

Game Properties	Relevant Constraints	Desired Game Characteristics
Complexity	1,3	Moderate complexity
User Interface	1,2	Easy to use interface
Difficulty	1,2	Low to medium difficulty
Subject matter	-	Appealing theme
Participation	3	Balanced individual participation
Unique roles	3	Players have unique roles
Social interaction	3	Need for verbal communication
Collaboration patterns	3	Sufficient use of collaborative patterns
Synchronicity	1,3	Concurrent play

3.2 Operation Sting

Operation Sting is a 3- or 4-player collaborative game in which team members work together (in concurrent play) to pull off a heist in an art museum. Each player is assigned a unique character with special abilities. The Conman character can use a lock pick to open padlocked doors and temporarily distract security guards. The Muscle is able to move around heavy objects and use items such as a crowbar to break down weak walls and windows. The Hacker can access sensitive information from computer terminals and disable cameras and laser detectors. Finally, the Executive has money that can be used to bribe certain individuals to overlook transgressions and is able to gain access to VIP areas of the museum. In the 3-player version, the role of the Executive is eliminated. Figure 1 shows each of the characters in Operation Sting.

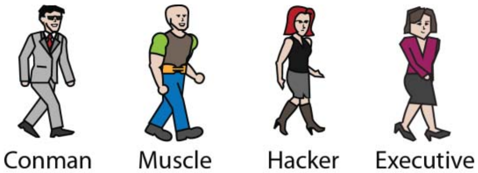

Figure 1. The 4 playable characters in *Operation Sting*

The game consists of a single heist mission where the 4 characters infiltrate the museum, each from a different location. The players must navigate through areas on the map and overcome different obstacles. As in real project or collaborative work environments, players are put into situations where they need to rely on each other's individual abilities to move forward. For example, access to a padlocked door revealing a new area may be blocked with several wooden containers. The Muscle would need to first move these containers out of the way before the Conman can pick the locked door.

With respect to the icebreaking video game requirements discussed previously, *Operation Sting* is a moderately complex, obstacle-solving, concurrent 2D game with easy-to-use controls (directional arrow keys and spacebar on the keyboard). Furthermore, the group heist theme used in the game is quite common in popular culture and should hopefully be familiar to all players. The game assigns each of the players a unique role with special abilities and obstacles are set up in a way that each player can make a roughly equal contribution to progressing through the mission. Finally, the special abilities granted, the unique information presented to specific players, and the use of shared obstacles require players to interact with one another in many situations to progress through the game. *Operation Sting* is designed to be played in 20-30 minutes by co-located teams around a single table so as to encourage social interaction and verbal communication. Figure 2 shows a screen shot of a game in progress from the point of view of the Muscle player.

Operation Sting is implemented in the style of a 2D overhead projected Role Playing Game (RPG). Multiplayer gaming is supported using a client-server architecture. The game client was developed using Adobe Flash and ActionScript 3 and can run on a Desktop computer using either Windows or OSX as the operating system. The server is a Windows executable which was written in C#. Communication between the client and the server relies on a 3rd party library (Player.IO) which makes use of the Transmission Control Protocol (TCP).

Figure 2. A game in progress from Muscle point of view. The key interface elements are marked.

4. PILOT STUDY

We conducted a pilot study with university students in a classroom activity [22] in which we compared participants in three conditions: 1. **Control** (did not participate in Operation Sting nor a non-game ice breaking activity); 2. **Game** (played Operation Sting); and 3. **Non-Game Icebreaker**: (participated in a non-video game icebreaking activity). We briefly outline the key results from the pilot study in order to present how group interaction compared in the three conditions. More details and results can be found in [22]. In the pilot study, students enrolled in a project management course in the Faculty of In-formation at the University of Toronto were assigned to teams of 3-4 people to participate in a synchronous computer-mediated activity (for 40-60 minutes) in order to collaboratively identify projects that could implement an organizational strategy. The computer-mediated activity was carried out in two steps: a brainstorming step in which each team brainstormed project ideas; a project identification step in which each team selected a final list from the list of project ideas produced in the brainstorming step. The two-step activity was inspired by the Brainstorming and Fast Focus thinkLets of Briggs et al. [2].

Teams were randomly placed into 3 groups: a) **Game:** Five teams played Operation Sting before participating in the computer-mediated project selection activity; b) **Icebreaker:** Four teams participated in a generic icebreaker game (Liar, Liar! [11]) before participating in the computer-mediated activity; and, c) **Control:** Seven teams participated in the computer-mediated activity without first playing Operation Sting or the generic icebreaker (i.e., control groups).

In order to measure interaction, we looked at the number of ideas (per group and per individual) and comments (per group and per individual) submitted during the Brainstorming and Fast Focus steps, respectively. We normalized the numbers by the time spent during each step and by group size. Error bars in Figure 3 and Figure 4 indicate +/- 1 standard deviation.

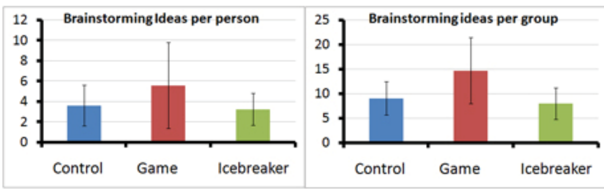

Figure 3. Mean number of brainstorming ideas per person across each category (left), and mean number of brainstorming ideas per group (right).

For the mean normalized number of individual and total ideas (using a two-tailed t-test), we observed p-values of 0.08 and 0.14 respectively for the Game-Control comparison and 0.05 and 0.10 for the Game-Icebreaker comparison.

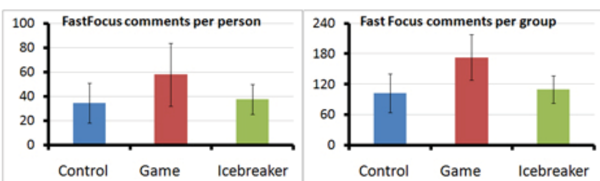

Figure 4. Mean number of Fast Focus comments per person across each category (left), and mean number of Fast Focus ideas per group (right).

For the mean normalized number of individual and total comments, we observed p-values of 0.002 and 0.02 respectively for the Game-Control comparison and 0.008 and 0.04 respectively for the Game-Icebreaker comparison. Collectively, these results suggest increased interaction in the Game category compared to the Control and Icebreaker categories.

5. METHOD

We conducted a study in an actual work setting within a public library system. Groups of size 3-4 were assembled from six different library branches (one group per branch) in order to participate in ~60 minute face-to-face meetings. During these meetings, each group brainstormed and discussed ways to improve the circulation of collections at their local branch (e.g. using collections management techniques such as weeding, updating collection profiles, promoting content through displays, etc.).

Groups were divided into two experimental conditions: 1. **Control** (did not play Operation Sting first); 2. **Game** (played Operation Sting first). Out of a total of 6 groups, half were in the Control condition (two of size 4 and one of size 3) and the other half were in the Game condition (two of size 4 and one of size 3). Because of the constraints of the real-world environment of the library branches, we were not able to compare the three conditions that were compared in the pilot study. Results from the pilot study indicate that similar interaction took place in the control and non-game icebreaker groups; therefore, in the real-work library experiment, we eliminated the non-game icebreaker condition and compared only the control and game conditions.

5.1 Participants

Participants from the library branches were asked to participate in the work task and invited to also participate in the study. In addition to institutional consent, individuals gave their informed consent before participating in the study. Each team consisted of staff from the same branch who knew one another but had not worked together in the specific group combinations used in the study.

5.2 Hypotheses

Our general hypothesis is that participation in the Operation Sting game increases collaboration among teammates in subsequent group work (compared with groups which do not play the game). In our experiment, we tested three specific hypotheses to examine different aspects of *increased* collaboration.

H1: Following the Operation Sting game, there will be increased group **interaction** among teammates in subsequent group work (compared with groups which do not play the game).

A useful way to look at coordination of efforts is to closely study the **interaction** that takes place among individuals in a group [18]. We measured this interaction by analyzing the number of words spoken and turns taken by the group. We also measured the number and total duration of pauses made by the group. Further, we analyzed *floor holding* [12] to identify how individuals worked together (or by themselves) to sustain a discussion.

H2: During subsequent group work after playing the Operation Sting game,

a) group members will demonstrate greater levels of individual **participation** (compared with groups which do not play the game); and

b) contributions made by individuals will be **distributed more evenly** across the group (compared with groups which do not play the game).

A minimum requirement for collaboration is an appropriate division of labor where individuals are responsible for their own share of work [10, 29]. We assessed the division of labor by looking at individual **participation** levels [18], specifically the number of words spoken by each individual and the distribution of words spoken by individuals within a group.

H3: Following the Operation Sting game, there will be greater group **cohesion** during the subsequent group work (compared with groups which do not play the game)

Cohesion is characterized as the group members' perceptions of the group as a totality [36]. We gauged individuals' attraction to the group and their satisfaction with the collaborative task through a post-activity survey, asking them to rate statements related to task cohesion, social cohesion, and individual attraction to the group [6].

5.3 Procedure

The groups worked together face-to-face. This configuration was used to take advantage of the icebreaking video game design. Video footage from all meetings was recorded using a stationary camera mounted on a tripod, directly facing the table at which participants were seated. A microphone placed in the middle of the table was used to record audio. An overhead view of the experimental setup is shown in Figure 5. When teams entered the room and were seated at the table, they were read a script reminding them of the goals of the work task (the script was written by a member of the library staff). Teams that played the game had laptops in front of them when they arrived. They were encouraged to play until successful completion or until 25 minutes were up. The game consisted of three completion checkpoints, with all teams completing the second checkpoint and one team completing the entire heist mission. After playing the video game, the laptops were removed from the table. Teams that did not play the game did not have laptops on the table when they arrived and launched right into the work task. We did not record the actual game play as we wanted the game play to be unencumbered, especially for inexperienced game-playing participants.

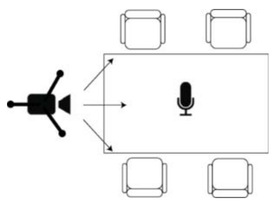

Figure 5. Overhead view of experimental setup

A silent observer was seated in the corner of the room to supervise recording equipment and make observational notes.

5.4 Data Analysis

For the purposes of analysis, audio recordings from each of the meetings were independently converted into complete electronic transcripts by 2 transcribers (1 researcher and 1 student assistant) who were blind to the conditions. All statements were recorded as speech turns and distinguished by participant ID (anonymized). These transcripts served as the primary source of data for subsequent analysis. We considered the total number of words spoken in our transcripts of the video footage. We also looked at the total number of speech *turns* taken by individuals. A *turn* is defined as a continuous utterance of speech by a single person without any interruptions OR sudden shifts in the direction of conversation (even if by the same person) [30]. During the transcription process, all speech was recorded in turns. In addition, we also looked at video footage to find instances where groups were silent for a specified duration (greater than 3 seconds) and when participants laughed together. We also had participants complete an individual survey to rate their group experience during the work task.

For a qualitative assessment, we coded floor-holding patterns during the conversation [12]. Floor holding occurs when a particular individual, or group of individuals dominate the flow of conversation for some period of time. A distinction is made between single floor holding (SF: where one person dominates) and collaborative floor holding (CF: when multiple participants are contributing to the discussion and there is no single individual dominating) [12]. A sequence of one or more turns was assigned a floor-holding code (using 1-4 characters) to denote the number of participants and which participants controlled the conversation during those turns. For example, a code of '13' indicates a collaborative floor holding (CF) session led by participants 1 and 3.

For reproducibility of results and to help the coders consistently interpret the data, we developed strict guidelines and rules to deal with ambiguity when coding. We had one coder go over the entire set of data and another one independently code a subset (470/3292 ~14% of the turns taken from different groups) in order to determine a weighted kappa value of 0.923 for inter-rater agreement (kappa calculation discussed in more detail in next section). Both coders were blind to the conditions.

We also considered the quality of the resulting circulation plans. Recall that the groups were expected to identify plans for improving the circulation of collections at their local branch. A senior member of the library management team reviewed and assessed the resulting plans but there was no significant difference in the resulting plans.

6. RESULTS AND DISCUSSION

6.1 Group Interaction (H1)

We found that groups that played Operation Sting interacted significantly more, both in number of words and turns, during the subsequent work meeting than those who did not ($t_{words} = 8.7$, $p < .05$, $t_{turns} = 3.5$, $p < .05$, using 2-tailed t-tests assuming unequal variances). In our analysis of the number of words spoken and the number of speech turns, we normalized data to a period of 60 minutes (as seen in Table 2). This was done because although each of the groups was instructed to spend 60 minutes during the meeting, because it was a real-work setting, differences in time spent by each of the groups were unavoidable (ranging between 40-65 minutes). These normalized values are presented visually in Figure 6 and Figure 7.

We observed that group size (C3 and G3 were of size 3 each and the rest were size 4) did not have an effect on the quantity of discussion, with $R^2 < .01$ for both words and turns (correlated to group size). We conjecture that this may have been because participants had to take turns talking and would not usually speak over each other.

We also counted the number (and duration) of pauses throughout the meeting. A pause is defined as a continuous period of time greater than three seconds, during which none of the participants speak. Groups in the Control condition had noticeably more time spent in pauses during their meeting than those in the Game condition (see Table 3). However this result was not statistically significant ($t = 2.2$, $p > .05$).

For qualitative analysis, we looked at the concept of floor holding in order to identify how individuals worked together (or by themselves) to sustain a discussion [12]. During collaborative floor holding, two or more people interact to direct the discussion compared to single floor holding when the conversation is directed by a single individual without interaction. We found that there was more collaborative floor holding than single floor holding in groups that played Operation Sting.

Table 2. The total number of words and turns for each group. The columns to the right marked (n) are normalized by the duration of each group meeting.

Group	Words	Turns	Time (min)	Words (n)	Turns (n)
C1	9000	420	65	8307.7	387.7
C2	8186	554	60	8186.0	554.0
C3	5544	291	41	8113.2	425.9
			Mean	**8202.3**	**455.9**
			S.D.	**80.24**	**71.12**
G1	11138	639	62	10778.7	618.4
G2	9615	644	58	9946.6	666.2
G3	10325	744	60	10325.0	744.0
			Mean	**10350.1**	**676.2**
			S.D.	**416.62**	**63.4**

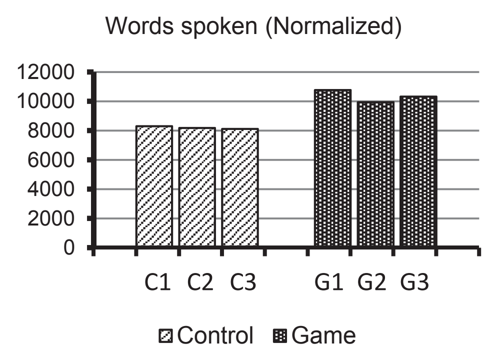

Figure 6. The normalized total number of words

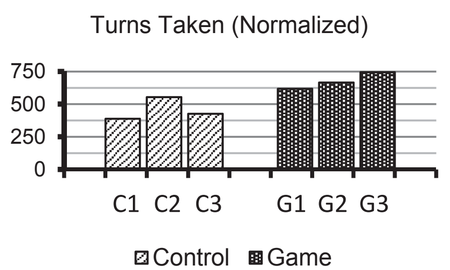

Figure 7. The normalized number of turns taken

Table 3. Number of pauses greater than 3 seconds as well as cumulative duration of these pauses

Group	No. of Pauses (> 3 sec.)	Time spent during pauses (sec)
C1	11	120
C2	46	445
C3	14	188
G1	0	0
G2	8	66
G3	4	36

We counted the number words spoken during single (SF) and collaborative (CF) floor holding. Going through turns one by one, we marked floor holding sequences (consisting of one or more turns) by identifying the participants who were controlling the conversation, and when transitions occurred between different individuals in control. For example, if participant 1 dominated the floor for a sequence of 5 turns (SF) before relinquishing control, these turns would be coded as '1'. On the other hand, if participants 2, 3, 4 consistently contributed to the conversation for 10 turns (CF) without any 1 person dominating, these turns would be coded as '234'. In order to compute the kappa value of 0.923 reported earlier, we assigned a weight of 0 to account for disagreements between SF and CF turns. To account for partial disagreements between CF turns, we calculated the weight as follows:

$$\text{Weight} = \frac{No.of\ participants\ in\ common\ between\ CF\ codes}{max(Length\ of\ Code\ 1, Length\ of\ Code\ 2)}$$

So for example, codes '13' and '1234' would indicate 0.50 agreement, '24' and '134' indicate 0.33 agreement. On the other hand, codes '2' and '234' indicate 0 agreement. The kappa value was calculated to be 0.923 (indicating strong inter-rater agreement).

After coding all the transcripts, we compared the number of words spoken during collaborative floor holding turns to those spoken during single floor holding turns. The ratios are shown in Figure 8 for each group, where we observe that most of the talking in the Game groups (greater than 50%) was done during CF turns, whereas in the Control groups, most of the talking was done during SF turns. This indicates that there was increased active participation from multiple individuals in the Game groups, and that major contributors to the discussion frequently alternated throughout the course of the meeting (individuals worked together more often to develop ideas during discussion).

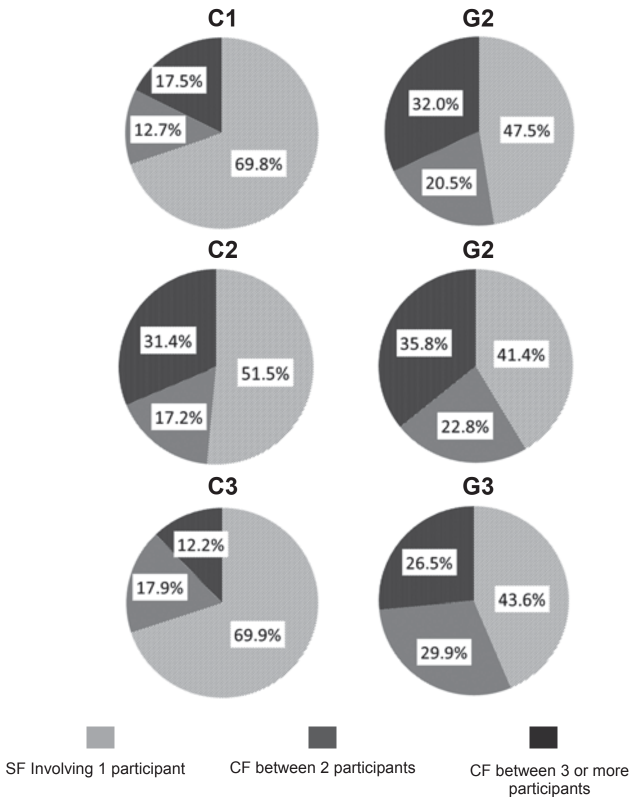

Figure 8. Ratios for conversation occurring during SF sequences, CF sequences involving 2 participants and CF sequences involving 3 or more participants

6.2 Individual Participation (H2)

In order to analyze *individual participation*, we looked at the percentage of words spoken throughout the meeting by individual. We found that individuals in the Game condition contributed more during the meeting in terms of words spoken than those in the Control condition.

Individual participation data is shown in Table 4, along with each person's percentage contribution to the whole group. We notice that groups C2, G1 and G2 each contain 1 individual who contributed very little to the overall discussion (<6%). These values add significantly to the variance within both the Game and Control conditions, resulting in weaker conclusions for hypothesis testing (given the limited amount of data) using a 2 tailed t-test (unequal variances).

If we focus the analysis on the top 3 contributors in each group (for groups of size 3, we consider all participants), those in the Game groups participated significantly more than those in the Control groups ($t = 2.3$, $p < .05$). The average across the top 3 contributors is 3284.7 words (std. dev. of 1072.8) for the Game condition and 2311.4 words (std. dev. of 690.8) for the Control condition.

Table 4. Number of words spoken (per person)

Group	Words	P1	P2	P3	P4
C1	9000	3228 *(35.9%)*	2206 *(24.5%)*	1862 *(20.7%)*	1704 *(18.9%)*
C2	8186	3092 *(37.8%)*	2442 *(29.8%)*	2429 *(29.7%)*	223 *(2.7%)*
C3	5544	2841 *(51.2%)*	1370 *(24.7%)*	1333 *(24.0%)*	-
G1	11138	3870 *(34.7%)*	3402 *(30.5%)*	3312 *(29.7%)*	549 *(4.9%)*
G2	9615	3724 *(38.7%)*	3147 *(32.7%)*	2174 *(22.6%)*	564 *(5.9%)*
G3	10325	5304 *(51.4%)*	3164 *(30.6%)*	1465 *(14.2%)*	-

Finally, we also looked at Participation Scores, which we define as follows:

Participation Score =
$$\sum_{users\ in\ group} \min\left(\frac{1}{Group\ Size}, \frac{No.of\ Individual\ words}{Total\ No.of\ Group\ words}\right)$$

Our comparison of the participation scores of groups across the 2 conditions did not result in any significant differences meaning that playing Operation Sting did not have an effect on the relative participation of individuals within the same group.

6.3 Group Cohesion (H3)

To assess *group cohesion*, we invited participants to complete a post-activity survey, asking them to rate statements on a 5-point Likert scale. The survey statements were grouped into 3 separate categories, based on the breakdown of Group Cohesion into three components: Task Cohesion, Social Cohesion and Individual Attraction to the group [6]. We did not observe any statistical differences between the two experimental conditions in the survey responses and were not able to find evidence to support the hypothesis that groups that played Operation Sting demonstrated increased cohesion. In general, groups in conditions were quite satisfied with their group and the work that was done during the meeting. Most individuals (8/11) in the Game condition stated they had little or no prior experience playing video games. In spite of this, they seemed 'to have had fun playing the game' (average score of 4.3/5). They also responded less favorably to the idea of 'diving straight into the meeting without playing the game' (average score of 2.2/5), suggesting that most of them preferred to play the game first.

Table 5. Number of instances where 3 or more individuals laughed together (for each group)

Group	Laughs	Group	Laughs
C1	26	G1	10
C2	30	G2	5
C3	11	G3	5

Finally, we went through the video footage of each group to find instances where three or more individuals laughed together (as shown in Table 5). Laughter has been thought to be a tool for building social cohesion [26]. We observed that all groups in the Control condition laughed more than those in the Game condition. This is a surprising result as we had anticipated an increase in laughter for Game groups, possibly indicating increased group cohesion and likeability. We speculate that the decreased laughter in Game groups may have been a consequence of individuals being more focused on the discussion. It may also have been possible that the icebreaking game afforded groups the opportunity to laugh and have fun together before the start of the meeting. However, since we did not record video or keep track of laughter during the gameplay sessions, it is not possible to confirm this.

7. DISCUSSION

We observed that groups that played the icebreaking game talked more, had more periods during which 2 or more people directed the conversation, spent less time paused, and laughed less. It's possible that playing Operation Sting resulted in the groups having an increased focus on the meeting during which multiple members interacted more on topics of discussion. However, we were surprised that the relative participation of individuals was not more evenly balanced in groups that played the game first. In 2/3 of the Game groups, there was one individual who contributed very little to the discussion. It is possible that equal participation is difficult when there is a quieter person or someone with less to contribute. Although not directly related to our hypothesis, we did notice that in almost all cases, participants who took written notes during the meeting contributed more to the discussion than those who did not. Future work should take into consideration how the roles which individuals take on during a collaborative task can impact their participation level.

We were also surprised that the survey data did not indicate any difference in group cohesion in groups that played Operation Sting. Although the participants in the study were co-workers, survey responses to whether they knew each other at a personal level were mixed (average responses of 2.55/5 and 3.27/5 for Control and Game conditions respectively). Future work could evaluate the effect of an icebreaking video game on groups of strangers vs. participants who know each other.

Finally, the increased laughter for Control groups may have been due to Game participants being afforded the opportunity to laugh and have fun before the start of the meeting. A future study could take a closer look at enjoyment levels during game play (and possible frustrations) and compare it to behavior in ensuing collaborative work.

8. CONCLUSION

In this paper we introduced a video game designed to serve as an icebreaker for collaborative work. We presented the results of a study conducted in a work environment in which ad-hoc work teams carried out a specific task and half of the work teams played the icebreaking game prior to participating in the work task. We found that playing the video game resulted in increased interaction during the subsequent work task as evidenced by number of words spoken and the ratio of collaborative floor-holding turns. We also found that individual participation increased in terms of number of words spoken; however, we did not observe an effect of playing the game on the relative participation of individuals within the same group. In terms of group cohesion, playing the video game did not appear to increase cohesion among the group; however, people enjoyed playing the game and favored that to diving straight into the meeting, even though most people who played the game had little to no prior experience with video games. We have demonstrated that there is potential for collaborative video games to serve as effective icebreaking activities for subsequent collaborative real work scenarios. In the future, it would be interesting to study the effect of different features in an icebreaking video game on different aspects of collaboration. It would also be interesting to measure the impact of different types of icebreaking video games (collaborative and competitive) on collaborative work tasks.

9. ACKNOWLEDGEMENTS

This research was supported by an NSERC Collaborative Research and Development Grant with SAP.

10. REFERENCES

1. Bartlett, K. and Simpson, M. Using games as a means for collaboration. In *11th International Conference on Multimedia Modelling Conference*, (Melbourne, Australia 2005), IEEE, 346-351.
2. Briggs, R.O., De Vreede, G., and Nunamaker, J.F. Collaboration engineering with ThinkLets to pursue sustained success with group support systems. *Journal of Management and Information Systems,* 19(4), 2008, 31-64.
3. Brown, B. and Bell, M. CSCW at play: 'There' as a collaborative virtual environment. In *Proceedings of 2004 Conference on Computer Supported Cooperative Work*, (Chicago, Illinois 2004), ACM, 350-359.
4. Brown, R. A. Conceptual modelling in 3D virtual worlds for process communication. In *Proceedings of the 7th Asia-Pacific Conference on Conceptual Modelling*, (Darlinghurst, Australia 2010), Australian Computer Society, 25-32.
5. Cao, X., Massimi, M., and Balakrishnan, R. Flashlight jigsaw: an exploratory study of an ad-hoc multi-player game on public displays. In *Proceedings of the 2008 Conference on Computer Supported Cooperative Work*, (San Diego, California 2008), ACM, 77-86.
6. Carless, S. A. and De Paola, C. The measurement of cohesion in work teams. *Small group research*, 31(1), 2000, 71-88.
7. Chen, M. G. Communication, coordination, and camaraderie in World of Warcraft. *Games and Culture*, 4(1), 2009, 47-73.
8. Dabbish, L. A. Jumpstarting relationships with online games: evidence from a laboratory investigation. In *Proceedings of the 2008 Conference on Computer Supported Cooperative Work*, (San Diego, California 2008), ACM, 353-356.
9. Deterding, S., Dixon, D., Khaled, R., and Nacke, L. From game design elements to gamefulness: defining gamification. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (Tampere, Finland 2011), ACM, 9-15.
10. Dillenbourg, P., Baker, M., Blaye, A., and O'Malley, C. The evolution of research on collaborative learning. In Reinman, P. and Spada, H. eds. *Learning in Humans and Machines: Towards an Interdisciplinary Learning Science*, Pergamon, New York, 1996, 189-211.
11. Dixon, J. S., Crooks, H., and Henry, K. Breaking the ice: supporting collaboration and development of community

online, *Canadian Journal of Learning and Technology*, 32(2), 2006).

12. Edelsky, C. Who's got the floor? *Language in Society*, Cambridge University Press, 10(3), 1981, 383-421.
13. Egenfeldt-Nielsen, S. Overview of research on the educational use of video games. *Digital Kompetanse*, 1(3), 2006, 184-213.
14. Ellis, J. B., Luther, K., Bessiere, K., and Kellogg, W. A. Games for virtual team building. In *Proceedings of the 7th Conference on Designing Interactive Systems* (Cape Town, South Africa 2008), ACM, 295-304.
15. Garris, R., Ahlers, R., and Driskell, J. E. Games, motivation, and learning: A research and practice model. *Simulation & Gaming*, 33(4), 2002, 441-467.
16. Goh, W.-B., Ting, L. G., Shou, W., Goh, C.-F., Menon, M., Tan, J., and Cohen, L. G. Potential challenges in collaborative game design for inclusive settings. In *Proceedings of Workshop on UI Technologies and their Impact on Educational Pedagogy* (Vancouver, BC 2011), ACM, retrieved August 23, 2015 from http://www.dfki.de/EducationCHI2011
17. Hämäläinen, R., Manninen, T., Järvelä, S., and Häkkinen, P. Learning to collaborate: designing collaboration in a 3-D game environment. *The Internet and Higher Education*, 9(1), 2006, 47-61.
18. Hathorn, L. G. and Ingram, A. L. Cooperation and collaboration using computer-mediated communication. *Journal of Educational Computing Research*, 26(3), 2002, 325-347.
19. Huang, Y., Ye, W., Bennett, N., and Contractor, N. (2013, February). Functional or social? exploring teams in online games. In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work* (San Antonio, Texas 2013), ACM, 399-408.
20. Khatib, F., DiMaio, F., Cooper, S., Kazmierczyk, M., Gilski, M., Krzywda, S., Zabranska, H., Pichova, I., Thompson, J., Popovi, Z., Jaskolski, M. and Baker, D. Crystal structure of a monomeric retroviral protease solved by protein folding game players. *Nature Structural and Molecular Biology*, 18(10), 2011, 1175-1177.
21. Nardi, B. and Harris, J. Strangers and friends: collaborative play in World of Warcraft. In *Proceedings of the 2006 Conference on Computer Supported Cooperative* Work (Banff, Alberta 2006), ACM, 149-158.
22. Nasir, M., Lyons, K., Leung, R., and Moradian, A. Cooperative games and their effect on group collaboration. In *Design Science at the Intersection of Physical and Virtual Design*, Springer Berlin Heidelberg, 2013, 502-510.
23. Pearce, C. Productive play: game culture from the bottom up. *Games and Culture,* 1(1), 2006, 17-24.
24. Qiu, L., Tay, W. W., and Wu, J. The impact of virtual teamwork on real-world collaboration. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology* (Salzburg, Austria 2009), ACM, 44-51.
25. Rieber, L. P. Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research and Development*, 44(2), 1996, 43-58.
26. Robinson, D. T. and Smith-Lovin, L. Getting a laugh: gender, status, and humor in task discussions. *Social Forces*, 80(1), 2001, 123-158.
27. Robinson, P. Task complexity, task difficulty, and task production: exploring interactions in a componential framework. *Applied Linguistics*, 22(1), 2001, 27-57.
28. Rocha, J. B., Mascarenhas, S., and Prada, R. Game mechanics for cooperative games. *ZON Digital Games,* 2008, 72-80
29. Roschelle, J. and Teasley, S. D. (1995, January). The construction of shared knowledge in collaborative problem solving. *Computer Supported Collaborative Learning,* 1995, Springer Berlin Heidelberg, 69-97.
30. Sacks, H., Schegloff, E. A., and Jefferson, G. (1974). A simplest systematics for the organization of turn-taking for conversation. Language, 696-735.
31. Seif El-Nasr, M., Aghabeigi, B., Milam, D., Erfani, M., Lameman, B., Maygoli, H., and Mah, S. Understanding and evaluating cooperative games. In Proceedings of the 28th International Conference on Human Factors in Computing Systems, (Atlanta, Georgia 2010), ACM, 253-262.
32. Sharma, G., Shroff, G., and Dewan, P. (2011, March). Workplace collaboration in a 3d virtual office. In *Proceedings of the 2011 IEEE International Symposium on VR Innovation*, (Singapore 2011) IEEE, 3-10.
33. Sweetser, P. and Wyeth, P. (2005). GameFlow: a model for evaluating player enjoyment in games. *Computers in Entertainment*, 2005, 3(3), 3-3.
34. Toups, Z. O., Kerne, A., and Hamilton, W. Game design principles for engaging cooperative play: core mechanics and interfaces for non-mimetic simulation of fire emergency response. In *Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games* (New Orleans, Louisiana 2009), ACM, 71-78.
35. Von Ahn, L. and Dabbish, L. Designing games with a purpose. *Communications of the ACM*, 51(8), 2008, 58-67.
36. Widemeyer, A. C. W. and Brawley, L. R. (2007). The development of an instrument to assess cohesion in sport teams: the group environment questionnaire. *Journal of Sport Psychology*, 7(3) 1985, 244-266.
37. Yoon, J., Oishi, J., Nawyn, J., Kobayashi, K., and Gupta, N. FishPong: encouraging human-to-human interaction in informal social environments. In *Proceedings of the 2004 Conference on Computer Supported Cooperative Work,* (Chicago, Illinois 2004), ACM, 374-377.
38. Zagal, J. P., Nussbaum, M., and Rosas, R. A model to support the design of multiplayer games. *Presence: Teleoperators and Virtual Environments*, 9(5), 2000, 448-462.