How do teams complete tasks in Virtual Worlds

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Abstract
Given the unique affordances of virtual worlds, it is important to study how teams function in such environments to complete tasks. One framework that has been used to understand how teams function is the punctuated equilibrium (PE) model, which provides an explanation for how teams complete tasks in a temporal frame, but falls short in explaining why teams carry out processes in certain ways. Preliminary analysis of data collected from 84 teams performing a complex decision-making task in the virtual world of Second Life shows evidence for the PE model. However, there is also evidence of unique social and contextual affordances of virtual worlds that enable members to use boundary objects and revise individual and shared mental models as they interact. Based on these preliminary results, we hope to arrive at a model of how teams complete tasks in virtual worlds.

Keywords
Punctuated equilibrium, Boundary objects, Mental models, virtual worlds, team work, decision-making

Introduction

While research on groups interacting in computer-mediated environments is not new, virtual worlds have unique affordances that differentiate them from prior technological environments. In particular, virtual worlds allow for a sense of context or location in which an activity can be situated, as well as a sense of others working in the same space (Goel et al., 2013). Given these unique affordances, it is important to study how teams function in such environments to complete tasks. In particular, we are interested in decision-making tasks since organizations often struggle with using technological environments to successfully bring together geographically dispersed teams for organizational decision-making (Maznevski and Chudoba, 2000).

One framework that has been used to understand how teams function is the punctuated equilibrium (PE) model. Originally proposed by Eldredge and Gould (1972) to explain zoological processes, the model was adapted by Gersick (1989) to explain teamwork. Gersick's model posits that teams do not necessarily follow a linear progression as they advance through their tasks, but rather go through long periods of inertia that are punctuated by concentrated revolutionary periods of quantum change, which usually occur at the midpoint of the teams' life.

While the PE model provides an explanation for how teams complete tasks in a temporal frame, it falls short on explaining why teams carry out processes in certain ways. The lack of such an explanation may be a reason for the inconclusive empirical support for this model (Chang et al., 2003). Prior research has identified certain boundary conditions under which the explanatory power of the PE model holds (Dennis et al., 2006). In particular, groups that have a shared understanding, and mechanisms to enable shared understandings, seem to follow the PE model. However for the most part, this research has been restricted to face-to-face settings, and does not provide theoretical bases for such boundary conditions.

We supplement the PE model to explain why certain group processes occur. Specifically, the concept of boundary objects enables us to describe mechanisms through which members of a group can arrive at a shared understanding, and the theory of mental models enables us to describe the nature of the shared understanding reached. As a first step, we develop a theoretical framework that draws on three theories. While we have completed the data collection phase of the study, our analysis has not been finalized. For this paper, we present details of the research plan and data collection from teams presented with a decision-making task in a virtual world, and report initial observations. We conclude with possible contributions that this study may make upon completion to research and practice.
Theoretical Background

Punctuated equilibrium

IS research has applied the punctuated equilibrium model to study IT alignment (Avison et al., 2004), systems development and change (Lyytinen and Newman, 2008), software adoption (Lassila and Brancheau, 1999), and system implementation (Segev et al., 1997). While not applied explicitly, the PE model has been suggested as important in understanding virtual team processes (Chidambaram and Bostrom, 1996). And, we are not aware of studies that apply the PE model to teams that complete a task in a virtual world environment. Given their distinct affordances, virtual worlds, or 3D computer-simulated environments, necessitate the testing and extension of theories that traditionally apply to other computer-mediated environments (Saunders et al., 2011).

The PE model as applied to team processes can be described in three distinct temporal components: Phase 1, Midpoint transition, and Phase 2. In Phase 1, the group maintains a certain stance towards a task that is assigned to them. This stance is usually determined by the end of the first meeting of the group, and is maintained throughout the first half of the team’s life (Gersick, 1989). The stance describes whether team members accept or object to the assignment, are certain or uncertain about what to do in the task, and whether team members converge or diverge with each other. Midpoint transitions are abrupt punctuations that occur around the midpoint of a group’s life due to temporal pacing, i.e. the awareness of time having elapsed, as well as problemistic search, i.e. the effort to integrate external information and stimuli. Transitional advances after the midpoint depend on the combination of Phase 1, learning, and fresh ideas. The team undergoes an upheaval and changes course to align itself with task completion objectives. The nature of this upheaval depends on the dissonance between the group’s initial stance and the objectives. Overall, the main themes identified by the PE model for group work are group stance (determined in Phase 1), a punctuation, which occurs around the mid point of a group’s life, and goal-directed work, which occurs in Phase 2. Critiques of adapting the PE model to group or organizational contexts suggest using a stage model to reframe the phenomenon (Lichtenstein, 1995). However, the proposed substitute models closely approximate the dynamics of PE.

The PE framework describes how group processes occur over a temporal span. However, it falls short in explaining why they occur. Empirical results of applying the PE model to groups have been inconclusive, where some teams have been observed to follow a PE model, and others not (Chang et al., 2003). Subsequent research has identified boundary conditions under which the framework is supported (Dennis et al., 2006). An implication is that internal group dynamics play an important role for group work and influence the extent to which a group follows a PE model in its processes to complete a task. In particular, shared or common understanding of the task is important, as are mechanisms (such as scripts) that enable members of a group to arrive at such shared understandings. We introduce two concepts that may shed light on why these conditions are important.

Boundary objects

The concept of boundary objects was developed by Star and Griesemer (1989) as a way to explain co-ordination work. Carlile (2002) applied the concept of boundary objects to specifically study knowledge representation and transfer across knowledge boundaries, such as those that might exist between individuals in a group. Boundary objects establish a shared point of reference for individuals to represent and jointly transform their knowledge (Carlile 2002). Their structure is such that it can take on different meanings for individuals, and yet is common enough to make them recognizable. For example, the map of a country may be topographical or political, and yet is recognizable as a map of the country. IT artifacts such as databases and schematic representations (e.g. workflow diagrams or entity-relationship diagrams) serve as boundary objects in organizations. Repositories such as databases provide a common reference point of data, measures, or labels across functional areas that establish shared definitions and values for problem solving.

Essential to boundary objects is the notion of shared syntax and semantics such that knowledge can easily flow between individuals. In Dennis et al.’s (2006) study, common scripts served as boundary objects enabling group members to exchange information. Hence boundary objects serve as mechanisms that allow members in a group to exchange information, enabling a common understanding of the task to develop. We use the theory of mental models to explain such an understanding.
Mental Models

Mental models (or cognitive maps) are psychological representations of real, hypothetical, or imaginary situations that help individuals make inferences and take actions (Holland et al., 1986). Each mental model is a possible state of affairs in the world (Johnson-Laird et al., 1998). Mental models are internal, inherently limited (since we cannot have mental models for all possible states of affairs), and responsible for our understanding and knowledge of the phenomenon that they represent. Mental models are “constructed” as a result of perception, imagination, and the comprehension of discourse (Craik, 1943). When different mental models are presented, group members are likely to work on resolving the differences and synthesizing mental models so that the group comes to a common understanding on the theme. This is known as “shared” or “team” mental model (Klimoski & Mohammed, 1994). Besides possible negative effects, such as “groupthink”, being able to arrive at shared mental models has been linked to group decision making, coordination, and learning (Mathieu et al., 2000).

Research Method

Sample

Subjects for this study are 343 students enrolled in an introductory IS course at a large, public university in the southern U.S. The sample of students is considered as representative of the target population to which this study wishes to contribute; they are the generation of IT workers most likely to use VW technologies in the next few years. Subjects received extra credit for their participation. Their average age is 21 years, almost evenly split between males and females. More than 93% consider themselves very or extremely familiar with computers (µ=6.22); 58% consider themselves familiar or extremely familiar with 3D computer games (µ=4.67); 15% had used Second Life before the experiment. Data collection was done over five months from 84 teams that varied in sizes of 3, 4, and 5 subjects. Each of these teams worked on the same decision-making task. Subjects were randomly assigned to teams.

Study Protocol and Data Collection

We chose a quasi-experiment, rather than a true experiment since we did not wish to look at multiple conditions (such as a control and experimental condition), but rather focus on natural processes by which teams completed the tasks. A “meeting room” was built exclusively for the purpose of this study on a private “island” in Second Life. As part of the experimental setup, five avatars were pre-created with a unique male or female look stored as a template. While subjects were filling out an initial demographics questionnaire, the researcher logged into each respective avatar and changed its gender to match that of the respective subject. This was done from the researcher’s machine with the subjects being unaware. The researcher, while remaining logged into Second Life, did not participate in the group’s task. After the groups had completed the task, they were instructed to quit the Second Life application. While no explicit time limit was set for the task, all teams completed the task between 50 and 90 minutes.

The task chosen for the actual data collection can be characterized as a complex cognitive decision making task. As opposed to simple tasks, complex tasks can have multiple solutions and multiple ways to achieve a solution (Campbell 1988). Complex tasks fit within the context that the punctuated equilibrium model would apply based on prior work (Gersick 1991). We focus on temporary teams that meet one time to complete a decision-making task. The software automatically recorded all interactions within the virtual world environment. The interactions include communication between subjects, gestures, as well as actions of the subjects while doing the task. The transcript for each team was downloaded as stored as a separate log file. The final dataset included 84 log files of approximately 12500 lines of text.

Data Analysis

We treat the logs as narratives. In our interpretation, we will highlight those aspects of the data that serve as evidence of the PE model, boundary objects, and mental models. Thus we will look for evidence of theoretical themes in our data, while being open to “emergent themes” that provide analytical insights to extend the theories (Bleichner, 1982). Based on a preliminary analysis of our data, we report our initial observations below. We present these with the caveat that they are based on a subset of our data; we have only analyzed 20 log files, and our research is still in progress.
Initial Observations

While we find support for the idea that group work and development does not occur in discrete stages, but rather through periods of inertia punctuated by short disruptions, we see some discrepancies in how this occurred in our pilot sample. Firstly, the PE model posits that groups assume an initial stance towards the task in a very short period after the group is formed. The stance is held throughout the first phase with very little changes. We find that there is indeed a first phase where groups try to arrive at a stance. However, this is determined through a long period of negotiations where each group member tries to gain awareness of the environmental and social context. Gradually, individuals “make sense” of where they are, who they are with, and what they are to do there with the others.

Secondly, the PE model assumes one punctuation that occurs around the midpoint of the group’s life. This punctuation occurs due to temporal pacing and problemistic search – both external triggers. The outcome of this brief punctuation is a new stance based on fresh ideas generated due to integration and learning that occur during the punctuation. We see initial evidence of multiple punctuations that may not be equal in magnitude. Also, triggers for the punctuations can be internal. We see evidence of “tinkering” (Ciborra, 1994), learning, and integration during this phase. External inputs may be sought as part of the tinkering, learning, and integrating process – but external inputs alone do not advance group work/development. The outcome of each punctuation is increased task understanding. While “tinkering” is not discussed in the PE model, it can be explained by the two theories to supplement the PE model.

The theory of mental models posits that everyone has a mental model that frames their knowledge regarding a certain phenomenon. For an unknown task, this mental model is not yet formed, leading to cognitive dissonance between what is known (or unknown) and observable phenomenon. Everyone tries to reduce this dissonance, i.e. one tries to make sense of the unknown phenomenon. Mental models can also be shared. Ideally, the aim of group work is to arrive at a shared mental model of a phenomenon that incorporates all individual mental models and this resultant model fits with the observable phenomenon. Boundary objects help accomplish that.

In Phase 1, making sense of the environmental and social context provides a starting point for a mental model. The subsequent iterations happen due to incremental development of mental models. Each punctuation is a new stage of mental model development. In order to arrive at the punctuation, individuals need to tinker, learn, and integrate knowledge into their mental models. If this does not occur, cognitive dissonance remains, punctuations do not occur, and group work does not advance. In order to tinker, there should be a way for individuals in the group to express their mental models to others (externalize), and talk about it through shared reference points. These are boundary objects. The affordances of virtual world enable boundary objects that can take the form of shared 3D virtual artifacts. Shared mental models can be developed through verbal and non-verbal communication such as “pointing” at, or “looking” in the same direction as team members. A sample of quotes below illustrates the process of arriving at shared mental models using boundary objects.

<table>
<thead>
<tr>
<th>Subject 1</th>
<th>Subject 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behind me is the connection for the two hubs and hub 2 to each node</td>
<td>Point to the one you think is the central connector?</td>
</tr>
<tr>
<td>I’m assuming a node is a computer?</td>
<td>Yes a node is a computer!!</td>
</tr>
<tr>
<td>I just understood how to connect =)</td>
<td>How so?</td>
</tr>
<tr>
<td>By clicking?</td>
<td></td>
</tr>
<tr>
<td>yes, just click on green under connect on the wall</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Sample quotes

Finally, The PE model posits that Phase 2 is another long period of inertia characterized by a new stance that was the outcome of the midpoint punctuation. We did not find support for a period of inertia in our initial sample. Instead, the brief cycles of punctuation continue until a) the group arrives at a shared group mental model or b) the mental model of one more individuals in the group fits the solution, and the others accede.
Conclusion

Our study attempts to understand how teams conduct decision-making tasks in virtual worlds. As a first step, we adopt a theoretical framework based on Gersick's punctuated equilibrium model of teamwork, boundary objects, and mental model theory. We find clues that the PE model may not apply as-is in the context of virtual worlds. Unique affordances of virtual worlds come into play as team members use boundary objects to revise individual and shared mental models. We offer preliminary insights into themes that have emerged thus far. For example, we see evidence of a prolonged phase 1 of “sense-making”, multiple punctuations throughout the duration of the team, and internal triggers such as “tinkering” that advance the learning and understanding of the team. We plan to build on these results to derive and test hypothesis in the context of decision making in virtual worlds.

REFERENCES