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Abstract

This research-in-progress paper investigates the impact of social structures in virtual worlds (VWs) on the diffusion of innovations within them. Research has illustrated that innovation diffusion takes place within virtual worlds. VWs facilitate the emergence of purposeful communities which support the (often real-world) activities of their members including the development and adoption of innovations. Thus, VWs alter the social structures in which their users are embedded and the manner in which they communicate, both of which are thought to influence the diffusion of technical innovations amongst individuals. Though technical innovation is at the heart of Information Systems (IS) research, empirical research investigating innovation in the networked age is in its infancy. Thus, this paper presents a framework of propositions in relation to the impact of social structures on the diffusion of innovations within VWs and proposes the use of social network analysis to investigate these propositions.

Keywords: Virtual worlds, innovation, diffusion, social network analysis

1 INTRODUCTION

The Internet is on the cusp of an evolutionary leap and today's virtual worlds (VWs) are seen as a sign of things to come (Driver 2008). Despite multidisciplinary interest in them, research investigating VWs is in its infancy. A review of extant literature reveals considerable conceptual imprecision surrounding VWs (Boellstorff 2008; Fetscherin, Lattemann et al. 2008); several terms are used to describe them, including virtual environment, synthetic world, and Web 3D; but concise definitions are "hard to find" (Boellstorff 2008, p. 17). As a result, the task of understanding VWs and innovation processes within them is difficult. Nevertheless, the need to do so is clear: approximately nineteen million people now participate in VWs (Jackson and Favier 2008) and more than US$200m is spent annually on virtual goods (Castronova 2005). In *Second Life* (SL®) alone, residents spent more than 28 million cumulative hours inworld in February 2008, created 200 terabytes of digital goods, with 50,000 businesses claiming profits (CPA 2008). Well known examples of innovative projects in Second Life include the artificial ecosystem Svarga, the audiovisual sculptures at Ramonia and Studio Wikitecture.

This study focuses on the diffusion of innovations in virtual worlds. The importance of innovation for organizational competitiveness is well recognized (Chesbrough 2003) and articulated (e.g. Tushman and Anderson 1986; Henderson and Clark 1990). Innovation diffusion is concerned with the communication of an innovation amongst members of a social system (Rogers 2003, p. 6). The formation, development and operation of VW communities are

influenced by their spatial and graphical properties, functional capabilities, communications and social networking mechanisms. Social Network Analysis (SNA) is deemed an appropriate vehicle to investigate innovation diffusion in VWs. The application of network models represents a "promising avenue" for innovation research (Cowan 2005). Rogers (2003, p. 361) suggests that adopting relationships as the unit of analysis represents the first step in overcoming the individual blame bias within extant diffusion studies and calls for study of the "network turbocharger effects", defined as "the additional variance… explained by network variables beyond the direct effect of the individual level variables". SNA recognizes the embeddedness of actors in social systems and holds that "the structure of relations among actors and the location of individual actors in the network have important behavioural, perceptual, and attitudinal consequences" (Knoke and Kuklinski 1982, p. 13). It has already been successfully used to study innovation adoption and diffusion (e.g. Coleman, Katz et al. 1966; Abrahamson and Rosenkopf 1997).

The study makes several contributions to IS research. It contributes a VW definition, derived from a review and extension of existing literature. It addresses a phenomenon (i.e. virtual worlds) of multidisciplinary interest and cross domain potential including simulation and communication (The New Media Consortium 2007; Atlas 2008); education and research (Bailenson 2002; Dickey 2005; Boulos, Hetherington et al. 2007; Duffy 2008); marketing and commerce (Castronova 2005; Hemp 2006; Driver 2008). It contributes to theory by presenting seven propositions regarding the impact of social networks on the diffusion of innovations in VWs. Once tested, these will provide insight into VWs and the diffusion of innovations. The paper is structured as follows. VWs are introduced, characterized and defined. Innovation diffusion and social network analysis are discussed in relation to virtual worlds. Finally, the paper presents a framework of propositions and concludes with a brief overview of how this study is operationalized.

2 VIRTUAL WORLDS

This section provides an overview of VWs and derives a definition of them which utilizes and extends extant literature, revealing them to be shared, interactive, immersive environments where participants can communicate, collaborate, innovate and trade. Today, it is estimated that approximately nineteen million people participate in VWs (Jackson and Favier 2008) and that more than $200 million a year is spent on virtual goods (Castronova 2005). VWs have evolved over three decades (Bartle 2004; Fetscherin, Lattemann et al. 2008) so despite their apparent novelty, they have important histories (Boellstorff 2008). Ever influenced by virtual reality and gaming, virtual worlds have become more graphically sophisticated over time (Sivan 2008), and continue to incorporate media of increasing richness. The origins of VWs can be traced to the release of *MUD* (multi-user DUNGEN[1]) in 1978. The first mainstream *social* world (*AberMUD*) was released in 1989 and *MOO* (1990) introduced the first fully functioning scripting language into a socially oriented world (Bartle 2004). It is commonly held that VWs progressed from text based to graphical environments, but several graphical environments were written in the 1960s (for instance *PLATO* (1960s); *Avatar* (1979); *Island of Kesmai* (1981)). The first three dimensional virtual world (*Meridian*) was released in 1996. As the Web evolved into a more explicit architecture of participation, VW users leveraged the vivid "opportunities for communication, collaboration, and cooperation" afforded by VWs (Fetscherin, Lattemann et al. 2008, p. 232) to deliver user-generated *content* far beyond that envisaged in Web 2.0 narratives. *There* was released in 2003 with its own currency (Therebucks), purchasable with 'real' money (Brown and Bell 2004). *Second Life*, released in 2003, incorporated "Linden Dollars" and was

[1] DUNGEN referred to the Fortran port used to play the game and is not actually a reference to the game Dungeons and Dragons (Bartle, 2004, p. 5)

billed as a "3D online digital world imaged, created, & owned by its residents" (Second life, 2007). The extent to which these mechanisms influence creativity in VWs is an open question.

Given the multidisciplinary interest in VWs (Fetscherin, Lattemann et al. 2008), the absence of clear definitions and an agreed upon terminology is to be expected. What follows is the articulation of a new definition of VWs ***as shared, interactive, immersive environments where participants can communicate, collaborate, innovate and trade***. VWs are **environments** and are referred to as places (e.g. Curtis 1992; Bartle 2004; Boellstorff 2008); spaces; environments (e.g. Bartle 2004; Mennecke, Roche et al. 2007); and simulations (Bartle 2004) of real or imaginary environments (Hagsand 1996). Bartle (2004, p. 475) argues that VWs are "a set of locations… People go to places, do things there, and then they go home". In other words, they are navigable (Hagsand 1996). In defining them as spaces, authors emphasize that these locations are not contiguously bound. Virtual world spaces can therefore include: (1) core public space (2) private space (private access but connected to public core) (3) private spaces (disconnected from public core) requiring teleportation (4) multi-scale spaces that break the rules of realism (e.g. a house inside a grandfather clock) (Dodge and Kitchin cited in Bartle 2004). VWs have their own "rules that enable players to effect changes to them"– in other words, they have their own "physics" (Bartle 2004, p. 3). A common misconception of VWs is that they are media: but as (Bartle 2004, p. 475) points out, a "medium is a channel open for communication with a (large) number of individuals. Although most VWs do contain channels, they are not themselves channels.

VWs are **shared** (Hagsand 1996), **multi-user** (Hagsand 1996; Bartle 2004), massively multiplayer (Mennecke, Roche et al. 2007) or distributed (Hagsand 1996). Their users are referred to as users (Curtis 1992; Hagsand 1996) but also as inhabitants (Bartle 2004), residents and participants (Mennecke, Roche et al. 2007). Implicit in the assertion that VWs are shared is the notion that the worlds exist independently of a particular user's presence within them. In other words, the worlds persist over time. Authors, seeking to emphasize the manner in which virtual world interactions are mediated by avatars, sometimes refer to 'characters or 'players' (Bartle 2004). This has led to the confusion of VWs and online games. VWs contain games. However, just as "the Pasadena Rose Bowl is a stadium, not a game" (Bartle 2004, pp. 473-475), VWs are environments distinguishable from the activities taking place within them.

VWs are **interactive** (Hagsand 1996; Cagnina and Poian 2007). Users are represented "inworld" as intentionally (and often lavishly) crafted characters known as 'avatars'. Participants interact with each other (Cagnina and Poian 2007) and engage in "socialization, entertainment, education, and commerce" (Menneke, Roche et al 2007). They also interact with the environment itself (Hagsand 1996; Bartle 2004; Cagnina and Poian 2007; Mennecke, Roche et al. 2007); building objects and embedding new functionalities. This functionality has enabled a new departure in user-generated content and has evolved to varying degrees in different VWs. Increasingly; people interact with 'bots' which have been built by other people within virtual worlds. Interactivity contributes to what has been termed social presence, defined as the degree of salience of another person in an interaction and the consequent salience of the interpersonal relationship (Short, Williams et al. 1976). Thus, key facets of VWs include "interconnection… social relationship… [and] network externalities" (Cagnina and Poian 2007).

VWs are **immersive**, where immersion is defined as that sense of "being there" or more formally as "a psychological state in which the individual perceives himself or herself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli" (Bailenson 2002). In defining VWs as immersive environments, it is necessary to consider the relationship between VWs and virtual reality. Contemporary three dimensional VWs in particular, have been associated with the concept of Virtual Reality (VR) (Boellstorff 2008) and there is considerable overlap between descriptions of the two. For instance, VWs feature "immersion, interaction and imagination" (Zhu, Xiang et al. 2007) and McLellan (2003) defines

virtual reality as "interactive and evoking a feeling of immersion." VR refers to (typically quite expensive) technological hardware, which is used to allow one to experience "worlds that never were and can never be" (Brooks in Biocca and Levy 1995, p. 6). VR technologies include (1) visual displays (2) graphics rendering systems (3) tracking systems and (4) database construction and maintenance systems (Brooks 1999, p. 16). The focus of VR research has traditionally been the technology itself and in increasing its "immersive and involving properties" rather than on the experience it creates (Steuer in Biocca and Levy 1995, p. 33). The immersion traditionally sought in the development of VR technologies is thus based on perceptual subterfuge or sensory realism leading to a "perceptually based illusion of non-mediation" (Lombard and Ditton 1997) within simulated environments. The immersiveness of these technologies has been defined as the "degree to which… [it] submerges the perceptual system of the user in computer-generated stimuli" (Biocca and Delaney in Biocca and Levy 1995, p. 57). VWs are also immersive. But the technologies used are inexpensive and typically rely on desktop interfaces. The emphasis is less on the technologies used than on the worlds themselves (Bartle 2004; Boellstorff 2008, p. 5) and they "approximate aspects of reality – enough for the purposes of immersion" (Bartle 2004, p. 475). See Table 1 below for a list of prominent virtual worlds.

NAME	RELEASED	SIGNIFICANCE
SecondLife	2003	Linden dollars; new revenue & IP policies for user driven content
There	2003	Therebucks
EverQuest	1999	Roaming camera; became a "standard"
UltimaOnline	1997	Rich environment ; Classless role playing
ActiveWorlds	1997	Influential for educational users
Meridian 59	1996	First (first person) 3D world
World of Warcraft	1994	Currently most popular MMORPG
MOO	1990	Scripting language; Morphed into LamdaMOO
LamdaMOO	1990	Most widely used distribution of MOO
Tiny MUD	1989	First social world; allowed user extensibility; became TinyMUSH
Tiny MUSH	c. 1989	Role playing emphasis; open source
LPMUD	1989	Enabled user functionality within worlds with a scripting language
DikuMUD	1991	Sophisticated codebase; Enabled user created worlds
AberMUD	1987	Successful itself; inspired DikuMUD, LPMud, TinyMUD
Federation	1988	Non-fantasy
Avatar	1979	Graphical
MUD / MUD2	1978	Multi-user; Inspired AberMUD

Table 1. Prominent virtual worlds listed in reverse chronological order

Second Life (SL) is seen as the *de facto* virtual world for commerce (Kim, Lyons et al. 2008). SL is the brainchild of Philip Rosedale and is managed by Linden Labs. SL is inhabited by millions of users and described as a user-generated content platform (Au 2008). Linden Labs describe it as "an online, 3D virtual world imagined and created by its residents" (Linden Research Inc 2008). Second Life is of particular interest because it embraces "strong economic and legal connections to the real world" in order to maximize the quality and quantity of its user-created content (Ondrejka 2005). Its key feature is the capability of its users to "collectively create" (Au 2008). Second Life residents have built replicas of real world locations, held "inworld" art openings, music concerts, and orchestral performances, and increasingly are using the medium to hold meetings, conferences, and teaching seminars (Jennings et al 2007) using a combination of built in text and voice chat features and streaming media. The infrastructure in Second Life is designed to facilitate a virtual economy, incorporating a Linden Dollar currency system and supports the ability to set objects as "for sale" or as replicable on demand (Jennings et al 2007). The steadily increasing volume of virtual goods and services sold in SL drove mainstream media coverage of SL and prompted the entry of a number of real world businesses into it in 2006 (Jennings et al

2007). Future plans to facilitate the development of its economy include the development of enterprise-safe VWs and universal avatars (which would allow users to "seamlessly travel" between worlds (IBM 2007); cf. Morgado 2009). Unresolved issues include the impact of virtual world economies on real world economies (see Castronova 2005); taxation, intellectual property rights and legal issues. The issue of digital property is also important because property rights are critical to strong markets, businesses, and innovation (Ondrejka 2005).

This study focuses on the potential impact of virtual worlds themselves on the diffusion of innovations within them. The role of virtual worlds in the creation and diffusion of innovations is of particular interest given the increased prevalence of networked innovation and the extent of collaborative and user driven innovation already manifest within them. Research is now needed to investigate the particular forms that innovation in virtual worlds takes and the processes at play as they diffuse through virtual world communities and social networks. To that end, the next section reviews literature on innovation and diffusion of innovation.

3 INNOVATION AND ITS DIFFUSION

This section provides an account of innovation and diffusion research. It introduces the concept of innovation, summarizes extant research streams, and identifies gaps in innovation studies to date. It argues for the adoption of a network perspective to investigate innovation in VWs.

Most broadly, innovation "combines factors in a new way" (Schumpeter 1939, pp. 87-88). It is commonly defined as an idea, practice, object or material artifact that is *perceived as* new by an individual or other unit of adoption" (e.g. West and Farr 1990; Damanpour and Gopalakrishnan 2001; Rogers 2003, p. 12). The idea is described as creative or meaningfully unique (e.g. Fang 2008); useful; original; or influential (Mayar cited in Paulus and Nijstad 2003). It generates value by solving techno-economic problems (Yayavaram and Ahuja 2008) and results in social change (Rogers 2003, p. xvi) or at least "challenges the present order" (Van de Ven, Angle et al. 2000).

Research has identified innovation types and characteristics (e.g. Zaltman 1973; Rogers 2003); and proposed innovation process models, at organizational (e.g. Utterback and Abernathy 1975), group (e.g. Osborn 1963; West in West and Farr 1990), and individual (Rogers 2003) levels. Authors have focused primarily on the factors affecting the rate of adoption of innovations (e.g. Moore and Benbasat 1991; Taylor and Todd 1995; Rogers 2003) and patterns of innovation diffusion (purposeful or passive) across space and/or time. Organizational level research dominates (King in West and Farr 1990, p. 52). However, results at an organizational level have been inconclusive and inconsistent (Wolfe 1994). Authors (e.g. West in West and Farr 1990; Paulus and Nijstad 2003) note the absence of group perspectives on innovation and creativity. Instead, emphasis is placed on individual reflection in creative accomplishments (Paulus and Nijstad 2003); individual antecedent research is typically cross-sectional; and few place facilitators or inhibitors in theoretical frameworks (King in West and Farr 1990).

The inattention to group level innovation research is understandable in light of phenomena including groupthink (premature consensus leading to suboptimal solutions) (cf. Janis 1972); diminished accountability (Karau and Williams 1993); diminished motivation (Karau and Williams 1993); deindividuation; production blocking; evaluation apprehension; and free riding in interacting groups (Diehl and Stroebe 1987). However, the role of groups in organizational life generally and innovation particularly (Paulus and Nijstad 2003) is increasingly acknowledged. In particular, evidence suggests that computer mediation enhances group performance. Dennis & Valacich (1993) find that large computer-based groups may outperform nominal groups (who tend to outperform groups) for brainstorming activities. Further, computer mediation may diminish the salience of social status variables resulting in greater and more even participation

(Weisband, Schneider et al. 1995). Thus, research bridging individual and group levels is needed. The application of network models to this task represents a "promising avenue" (Cowan 2005).

A number of criticisms have been levelled at innovation research. Innovation studies have done little to improve our understanding of innovation in decentralized contexts (Rogers 2003, p. 395). What we think of as single innovations are often the outcomes of lengthy processes involving interrelated innovations (Fagerberg, Mowery et al. 2004). Individual innovations do change (often drastically) over time (Kline and Rosenberg 1986, p. 283) as a result of reinvention, recombination (cf. Van de Ven, Angle et al. 2000; Yayavaram and Ahuja 2008), borrowing and imitation (cf. March and Simon 1958), functional interdependency (Rogers 2003, p. 162), and knowledge spillovers (Cohen and Levin 1989). But research often fails to address these issues (Rogers 2003). A focus on innovation diffusion patterns may shed light on these issues.

Innovation diffusion is defined as the process in which an innovation is communicated through certain channels over time among members of a social system (Rogers 2003, p. 5). Rogers (2003, p. xviii) argues that the diffusion of the Internet itself alters the diffusion of innovations because it changes the interpersonal networks through which information exchange about a new idea takes place. Ryan and Gross (1943) first classified adopters based on time of adoption: classifying adopters as innovators, early adopters, early majority, late majority and laggards. Innovation diffusion studies have investigated eight classes of dependent variable: the rate of adoption of innovations, the innovativeness of social system members (individuals or organizations), the role of opinion leadership, the role of communication channels, diffusion networks, the earliness of knowing about an innovation and the consequences of an innovation (Rogers 2003, pp. 98-99).

In the IS domain, the adoption of technical innovation has received attention resulting in several theories (cf. Davis 1989; Moore and Benbasat 1991; Venkatesh, Morris et al. 2003). These theories demonstrate the importance of adopter perception in adoption decisions, but are "for the most part silent on how users form initial attitudes about technologies" (Melone in Karahanna, Straub et al. 1999). The adoption of the relationship between individuals as the unit of analysis in future studies (cf. Rogers 2003, p. 361) may prove a first step in the understanding of this process. Rogers (2003, p. 361) also calls for the investigation of "network turbocharger effects", defined as "the additional variance in a dependent variable explained by network variables beyond the direct effect of the individual level variables". The application of network models represents a "promising avenue" for innovation research (Cowan 2005). Nonetheless, relatively few studies of innovation diffusion have adopted a social network analysis approach. Social network analysis (introduced below) represents a promising approach for the investigation of innovation diffusion in virtual worlds. The next section introduces social network analysis (SNA). It is a necessary prelude to the discussion of propositions which follows.

4 SOCIAL NETWORKS: THEORY AND ANALYSIS

Social networks are patterns of friendship, advice, communication or support which exist among members of a social system (Knoke and Kuklinski 1982; Scott 2000). A social network consists of finite set(s) of actors and relation(s) defined on them; the inclusion of relational information is a defining feature of a social network (Wasserman and Faust 1994, p. 20). Social Network Analysis (SNA) was developed to counteract the overemphasis of individual attributes in sociological research (Knoke and Kuklinski 1982). SNA holds that "the structure of relations among actors and the location of individual actors in the network have important behavioural, perceptual, and attitudinal consequences"; it explicitly recognizes the embeddedness of actors in social systems (Knoke and Kuklinski 1982, p. 13). SNA seeks to explain the behaviour of network elements *in part* by examining the interconnections amongst elements (Laumann 1994, p. 394). The hallmark of a network based explanation of a process is the inclusion of concepts

and information on relationships among units in a study: theoretical concepts and pertinent data are relational; structures are operationalized in terms of networks of linkages among units (Wasserman and Faust 1994, p. 6). Table 2 summarizes the social network constructs relevant to this study.

Construct	Explanation
Centrality	*Point centrality:* local centrality (the relative prominence of a focal point in its neighbourhood) and global centrality (prominence in the context of the whole network). *Centralization* refers the overall cohesion or integration of the graph rather the relative prominence of points (Scott 2000). *Betweenness:* the extent to which a point lies "between" the various other points in a graph. It measures the extent to which an agent can act as a broker (Scott 2000, p. 86)
Density	Density refers to the general level of cohesion in a graph. Centralization describes the extent to which cohesion is organized around particular focal points. Density and Centralization are complementary measures (Scott 2000, p. 89). *Individual-level density* refers to the degree a respondent's ties know one another/ proportion of ties among an individual's nominees *Network density* is the proportion of ties in a network relative to the total number possible(networks may be sparse or dense)
Path length	The distances between pairs of nodes in the network
Social cohesion	A situation where individuals are connected directly to each other into sub-networks where either every actor is connected to all others (maximal connection) or there exists a social circle where each actor is in connection with at least 80% of the clique members (Burt, 1976). A cohesive group is one whose members are strongly attracted to one another where attraction refers to favourable sentiments toward others which find expression in an inclination to engage readily in social intercourse (Blau 1960)
Structural equivalence	Occupants of roles are structurally equivalent if they are to some extent interchangeable (Scott (2000, p. 123) uses the word substitutable), due to having similar linkages to the occupants of other positions (Lorrain and White 1971). Structural equivalence is concerned with the types of social relations maintained by categories of agents and is based on identifying uniformities of action which define social positions.
Contagion	Burt (1987) discusses social contagion in the context of innovation diffusion, suggesting that something about the social structural circumstances of ego and alter makes them proximate such that ego's evaluation of an innovation is sensitive to alter's adoption. Both contact and communication make ego and alter proximate (Burt 1987)
Structural hole	Static holes that can be strategically filled by connecting one or more links. The concept is related to social capital.
Radiality	Degree to which an individual's network reaches out into the network and provides novel information and influence
Reachability	The degree any member of a network can reach other members of the network

Table 2. Social Network constructs relevant to the diffusion of innovations in virtual worlds

The study of social networks has contributed to the development of social capital theories. Burt (1999) investigated the social capital of opinion leaders, whose role in the diffusion of innovations has been demonstrated by a number of empirical studies (cf. Rogers 2003). Burt (1992) examined the role of structural holes in social networks, postulating the existence of brokers who bridge those holes. Granovetter (1973) investigated the role of weak ties in the transmission of information across subgroups. Rogers (2003) developed the concept of localites and socialites and hypothesized that more cosmopolitan individuals would be comparatively more innovative. Lorrain and White's (1971) investigation of the effect of social cohesion on individuals led to Burt's (1987) analysis of social cohesion and equivalence in the context of social contagion.

In the next section, a number of propositions regarding the factors affecting innovation diffusion in virtual worlds are proposed and presented in the form of a theoretical framework.

5 PROPOSITIONS

This section derives seven propositions regarding the impact of virtual world social networks on the diffusion of innovations within them. These propositions are derived from a combination of virtual world observations (made in Second Life) and extant knowledge of social networks. The propositions are presented initially as a theoretical model (see figure 1 below); and pertain to three key aspects of the process and outcome of innovation diffusion, namely: (1) openness, (2) connectivity and (3) structural equivalence and social cohesion in virtual worlds. The seven propositions are organised under these three headings.

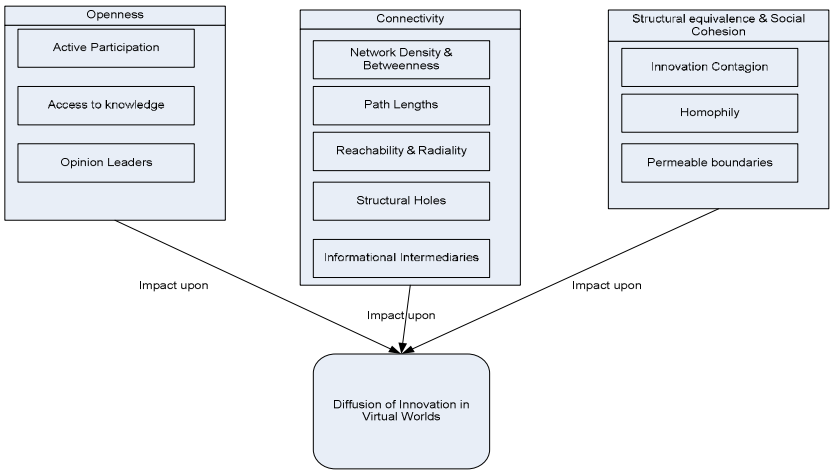

Figure 1. Preliminary model of the impact of VW social structure on the diffusion of innovations

5.1 Openness

People's perceptions of each other shape their interactions. Indeed the weight they give each other's opinions are often based on physical and social cues such as race, gender, age, or social standing (Weisband, Schneider et al. 1995). Previous research indicates that higher status group members dominate group activities but in computer mediated contexts, the salience of status effects is diminished, leading to greater participation (Weisband, Schneider et al. 1995). It is theorized that social status exists within VWs and is based on real world (where this information is disclosed) as well as virtual world factors (e.g. avatar appearance; newbie status).

However, the impact of social status on levels of interaction and participation is diminished in VWs leading to greater degrees of direct and equalized interactions.

Proposition 1: *There are high levels of participation in the VW innovation diffusion process*

Proposition 2: *Easy access to detailed (even tacit) knowledge of innovations in VWs, due to direct exposure to opinion leaders and change agents results in rapid innovation diffusion*

Computer mediated communication has typically been text-based and asynchronous with limited social presence (Wellman, Salaff et al. 1996). VWs facilitate high levels of presence, facilitating the formation of affective relations and personal contacts, which are thought to "provide more meaningful referents than broad social aggregates" (Gartrell 1987). Furthermore, as a result of high levels of participation in VWs, actors are more likely to have personal contact with high status members, including opinion leaders and change agents.

Proposition 3: *High status actors, including opinion leaders, will have greater influence on individual adoption decisions in VWs than real worlds*

5.2 Connectivity

Communication technologies within VWs are diverse and easy to employ. They support the ability to broadcast, locally or otherwise; multiplex communications (direct communications with multiple alters simultaneously using synchronous and asynchronous methods); and teleportation to spatially distant locations inworld. They therefore reduce the costs associated with maintaining a large number of relationships and may increase spatial as well as social proximity relative to the real world. This may facilitate the formation of large, (globally) dense social networks in VWs. Holes in social structure (referred to as structural holes) are thought to create competitive advantages for individuals whose networks span those holes (Burt 1992); to separate nonredundant sources of information; and to afford actors on either side of them the opportunity to increase their own social capital by brokering the flow of information across them (Burt 1999). Low costs associated with adding new linkages, greater network density and radiality as well as publicly available information on social structures in VWs decrease the likelihood that structural holes will be found in VW social networks and increase the ability of actors to circumnavigate them.

Proposition 4: *Innovation diffusion in VWs is accelerated in VWS due to high availability of (novel) information and the relative ease of accessing it*

> *Proposition 4(a): VWs have high levels of* network density *and low levels of* Betweenness
>
> *Proposition 4(b): VW social networks have relatively short* path lengths
>
> *Proposition 4(c): VW actors demonstrate high levels of* reachability *and* radiality
>
> *Proposition 4(d): The existence and significance of* structural holes *in VWs is minimal*
>
> *Proposition 4(e): The existence of informational intermediaries in VWs is minimal and their ability to, and benefits associated with, controlling the flow of information in VW networks are reduced*

5.3 Structural equivalence and social cohesion

Initial observation suggests that virtual world interactions are characterised by high levels of openness and connectivity. Empowered with social networking tools and freed from the spatial constraints of the actual world, users have greater control over the composition of their own social networks. Virtual worlds are theorized to allow structurally equivalent actors to come together to form purposeful and socially cohesive communities resulting in high levels of social contagion and homophily. Burt (1987) discusses social contagion in the context of innovation diffusion, suggesting that "something about the social structural circumstances of ego and alter makes them proximate such that ego's evaluation of an innovation is sensitive to alter's adoption". Both contact and communication have been argued to make ego and alter proximate (Burt 1987). High levels of interaction lead to increased similarity (Gartrell 1987). Homophily is the principle that contact between similar people occurs at a higher rate than among dissimilar people (Rogers 2003). Prior research indicates that homophily increases the rate of innovation diffusion but inhibits the diffusion of innovations across subgroups (Rogers 2003).

Proposition 5: *VW social networks feature high levels of innovation* contagion

Proposition 6: *VW social networks are* homophilious *increasing the rate of diffusion*

Proposition 7: *VW subgroup boundaries are permeable facilitating diffusion across subgroups*

6 CONCLUSIONS AND FUTURE RESEARCH

The diffusion of innovations in VWs is of scientific and practical interest for several reasons. For many organisations, VWs represent significant commercial and educational opportunities. For these organizations, an understanding of how innovations are diffused within VWs is of paramount importance. In an academic context, the literature focusing on VWs is still immature. Investigation of the propositions outlined in this study will make a significant theoretical contribution in helping researchers understand diffusion of innovation within virtual worlds. Thus, insights gained from this study will be of value to researchers and practitioners alike.

The model (figure 1) is being operationalised using a mixed method approach. The first phase is underway. It involves an initial period of participant observation informing the specification of a survey questionnaire. Jorgensen (1989, p. 12) argues that participant observation is relevant where "the phenomenon is obscured from the view of outsiders". The questionnaire is being pretested. The aim is to circulate the survey to members of Second Life's educational community, using data collected by Jennings et al (2007). Survey data will be triangulated using qualitative data from a single case, gathered using both interviews and participant observation. The need to use a combination of methods arises from known (and significant) deviations between self-report and behavioural data in social network studies (cf. Bernard and Killworth 1977). Thus, this combination of methods is deemed appropriate to probe the above propositions and refine the model presented in figure 1.

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