NUANCING: FIDELITY AND FLEXIBLE ADAPTIVITY IN THE IMPLEMENTATION OF TECHNOLOGY-RICH INNOVATIONS

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ABSTRACT

This manuscript reports on two studies on the implementation of a technology-rich innovation in public schools. This technology-rich innovation was an online quasi-video game environment that used 'through-the-window' virtual reality and a robust back story to situate learning activities in the virtual world for children. The first study examined the reasons why teachers chose to implement the innovation as well as the core challenges and supports necessary for the successful implementation of the innovation. This study used case study methodology and found that the innovation required a great degree of alignment between project goals and existing teacher needs and concerns. The second study re-examined data from the first study to explore how the innovation was actually implemented. The second study employed classic grounded theory methods for analysis and theory building. Nuancing theory emerged as the core category that arose as a result of the inductive grounded theory analysis procedures. This paper elaborates nuancing theory and addresses its possible applications to the problem of designing, developing, and implementing technology-rich innovations for situating learning activity in schools.

Keywords: Education, Educational Technology, Technology, Implementation, Design, Grounded Theory.

INTRODUCTION

A central problem in the human condition is how to replicate actions that have proven to be successful and how to apply them to new conditions, contexts, or situations. How can beneficial, innovative practices be transferred or diffused to new contexts? Rogers (1995) examined this problem in depth, exploring the characteristics of innovations that make them more or less likely to diffuse to new contexts. Connected to this are the characteristics of people who are more or less likely to take up innovative practices, the channels of diffusion, and the life cycles of innovations. In a career-long program of inquiry, Rogers (1995) found that people who are involved in diffusion efforts consider the relative advantage of the innovation, the compatibility, with current practice and context, the complexity of the innovation and its difficulty to adopt. They also consider its trial ability or the extent to which it may be tested or tried out before full adoption and its potential for reinvention or its ability to be adapted to unplanned for uses (Rogers, 1995). Considering the characteristics of the innovation, the fuzziness of the boundaries of the innovation may impact its ability to diffuse. Innovations that have a small set of core elements or practices are easier to diffuse than those with a larger core. Innovations that are riskier are less likely to diffuse. Innovations that are disruptive to existing contextual routines are less likely to diffuse. Innovations that make other tasks easier are more likely to diffuse. An innovation's difficulty to learn may also impact its diffusability. Rogers (2003) also categorized people in terms of their adoption proclivity. These are innovators, early adopters, early majority, late majority, and laggards. There are also gatekeepers and opinion leaders who can manage the diffusion of innovations in each community. An agent of change may come from outside the community and must work through community gatekeepers and then those who lead opinions in the community and then through the other categories until finally reaching laggards. Rogers (2003) also distinguishes adoption and diffusion. Individual adopt innovations while innovations diffuse through communities or groups of people. Rogers (2003) also lists five stages of adoption among individuals. These are, awareness, interest, evaluation, trial, and finally adoption. The innovation may be rejected and any point in this process. In short, when there is a new way of doing things, it can be very hard to get others to do it in the new way. And, as it turns out, there are some types of people who are more amenable to trying things in new ways and there are some who steadfastly refuse to change. From the standpoint of design, how can we create tools and ways of doing things and implement them in ways that will make their adoption easier and more enduring?

1. Fidelity vs. Flexible Adaptivity

The central issue in the adoption or implementation of innovations generally is the extent to which the innovation hangs together and does not change when it is implemented in multiple contexts in the real world. Designers of innovations that are intended to be implemented broad scale consider this a problem of fidelity. How well does the innovation hold together or keep its coherence when it is implemented in multiple contexts? Ideally, contextual alterations would be undetectable. From the fidelity standpoint, a perfect implementation occurs when there are no changes to the innovation when implemented (Figure 1). Ideas can change when they hit the field, but fidelity describes its resistance to change.

The problem, however, is that there can be no perfect implementation. Inevitably, the context of the implementation acts upon the innovation. In educational contexts, we can say that when a designed innovation meets a real-life, messy classroom culture, there are changes that occur in the implementation. Such changes represent a threat to the innovation because these changes were not planned for. They are departures from what the designers of the innovation wanted to accomplish and therefore represent a threat to the design and thus the success of the innovation. The appearance of these problematic changes is referred to as the "mutation phenomenon" (Berman & McLaughlin, 1974, p. 10) (Figure 2). Inevitably, implementation practices change in the field.

When an innovation is plagued by mutations in the implementation process, it becomes less effective and less able to accomplish its objectives (Figure 2). The gap between the intended innovation and what is actually implemented has been examined from the standpoint of the notion of fidelity in the areas of implementation research and implementation science (Fixsen, Naoom, Blase, Friedman, & Wallace, 2005; Fullan & Pomfret, 1977; Fullan, 1982; Snyder, Bolin, & Zumwalt, 1996). As changes or mutations find their way into the implementation of an innovation, its integrity and its potential effectiveness become questionable. If an innovation experiences profound changes "lethal mutations" may appear that can "kill" the innovation (Brown & Campione, 1996). An innovation could experience "cooptation" that occurs when it is taken over or "co-opted" by its hosts (Berman & McLaughlin, 1975, p. 10). Both lethal mutations and cooptation represent threats to educational innovations when they are implemented in multiple contexts. A persistent challenge is to get from designed for or paper implementation to actual process implementation (Hernandez & Hodges, 2003) and to view change as acomprehensive adaptation rather than mutation (Figure 3). Paper implementation occurs when there has been policy change and assessment or compliance measures, but with little more than perfunctory change in what people do. Process implementation occurs when training and

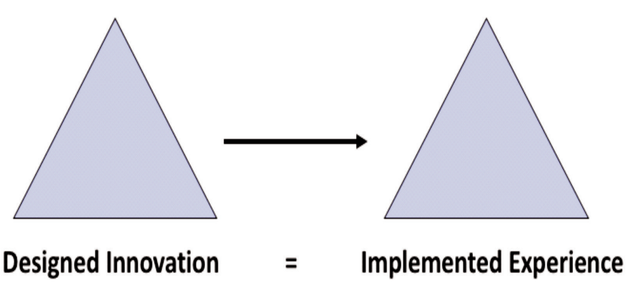

Figure 1. Ideal Implementation

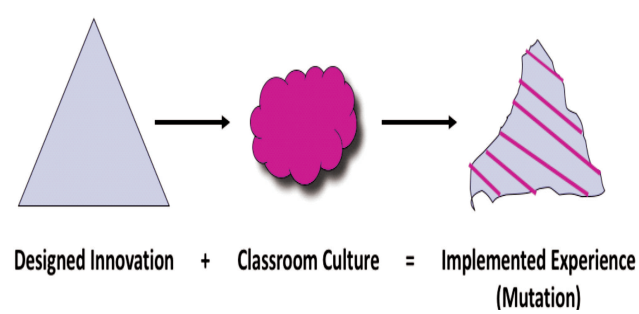

Figure 2. The Mutation Phenomenon

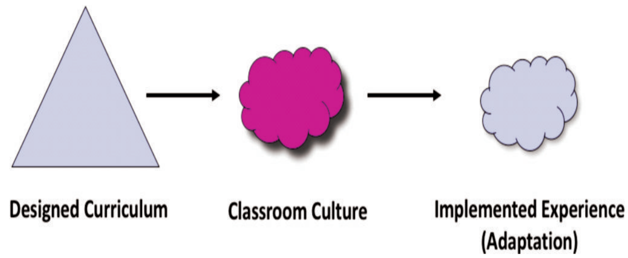

Figure 3. Adaptation

supervision are used to support the implementation. At this level, there is discussion about the change but this, again, is perfunctory. Performance implementation occurs when there is change in what occurs in common practice among those for whom the change was designed (Fixsen et al., 2005; Hernandez & Hodges, 2003).

Implementation should not just be a top-down process, but must involve bottom-up elements as well (Berman & McLaughlin, 1974; 1975; 1978; Rodgers, 1995). Top Down implementation efforts usually result in discontinuation of the innovation (Figure 4).

The realization that top-down approaches to implementation can be fraught with serious problems largely came about after the publication of a collection of reports that examined the implementation of broad-scale educational innovations conducted during the 1970s (Berman, Greenwood, McLaughlin, & Pincus, 1975; Berman & McLaughlin, 1974; 1975; 1978; Greenwood, Mann, & McLaughlin, 1975; McLaughlin, 1990). The central finding of these studies was that a top-down approaches to implementation usually fail. Instead, successful implementation efforts usually enjoy broad-based or grassroots support that lead to mutual adaptation and eventually institutionalized change (Figure 4). When

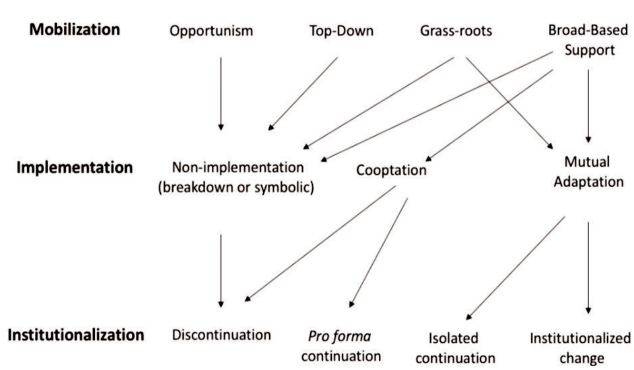

Figure 4. Implementation Efforts (Berman & McLaughlin, 1978, p. 17)

administrators try to muscle implementation or force adoption, the efforts usually fail. An inflexible innovation that permits no local customization will inevitably be overwhelmed by local contextual factors. In volume VIII of the Rand Corporation reports, Berman and McLaughlin (1978) state,

"The net return to federal investment was the adoption of many innovations, the successful implementation of few, and the long-run continuation of still fewer" (p. 10).

They concluded that what works well in one context simply may not work well in another. Cookie-cutter approaches don't work (Barab & Luehmann, 2003; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003; Barab & Squire, 2004). Furthermore, they fail to benefit from what local contexts can bring to implementation efforts and make new programs better. Deficit approaches fail to account for local cultures, proclivities, and personalities (Berman & McLaughlin, 1974; Elmore, 1996; Fixsen, et al., 2005; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003).

However, it is still possible for externally designed innovations to be effectively implemented in local contexts. As has been noted by Rogers (1995), reluctant adopters may become interested in implementing an innovation once they have the opportunity to see it implemented by colleagues. Having the opportunity to watch the implementation before fully committing to it is a useful approach as it allows participants to gain confidence in the innovation and in their own abilities to deal with it (Crandall, 1983; Guskey, 1986; Huberman & Miles, 1984). Programs that are externally created may be successful in educational contexts if teachers are given appropriate support, training, and are given some ownership and control over the innovation (Crandall, et al., 1982; Huberman & Miles, 1984; Miles & Louis, 1990).

The Rand studies on Federal Programs Supporting Educational Change suggested that 'mutual adaptation' might be appropriate for educational innovations (Berman & McLaughlin, 1975; Fullan & Pomfret, 1977; House, 1979). In this approach, local adaptation is not considered a threat to the program. Designers plan for program flexibility so that innovations can be allowed to adjust to local contexts (Randi & Corno, 1997). This approach would allow

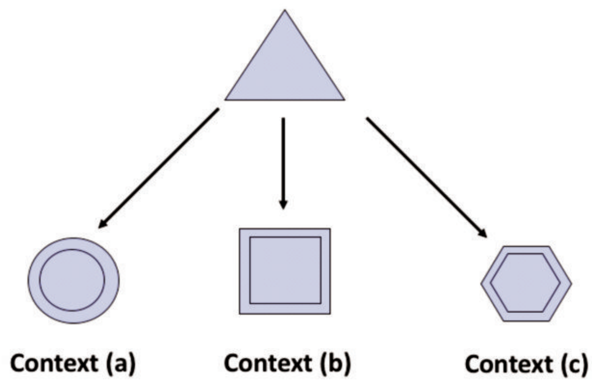

Figure 5. Flexible Adaptivity in Multi-context Implementation

an innovation to adjust to local contextual factors (Fullan & Pomfret, 1977; Snyder, et al., 1996) (Figure 5).

However, flexible adaptivity is an exercise in balance. The goal is to make something flexible so that it can adapt but firm enough so that it maintains its coherence. This requires a great deal of nuance in design and implementation.

2. Implementing Technology-Rich Innovations in Education

An innovation that centralizes the use of technology is one that may be described as "technology rich" (Thomas, Tuzun, & Barab, 2009). A category of designed innovations that has presented challenges to the education community is that of advanced technologies. These technology-rich innovations present a range of problems in implementation and are continuously in need of study (Cuban, 1986; 2001; Collins, 1992; Dede, 1998; Bauer & Kenton, 2005). Many researchers have focused on the role of teachers in the implementation of technology-rich innovations (Hsu, 2010; Gray, Thomas, & Lewis, 2010; Christensen, 2002; Cunningham, 1985; Purcell, Heaps, Buchanan, & Friedrich, 2013). According to Anthony, Hilliker-Vanstrander, Meskill, Tseng, and You, (2006), time and resources are two major reasons that explain teachers' reluctance to integrate technology-rich innovations into their teaching. Perrotta and Evans (2013) found that there can be serious political dimensions to educational technology implementation. They state,

"individuals tend to use educational technology and, generally, the discourse of innovation for political purposes, though these intimations often remain implicit" (Perrotta & Evans, 2013, p. 521).

They also mention that educational technology may be implemented by teachers in order to enhance opportunities for their careers or as a "resistance" to daily routines and drudgery and to explore individual interests. In this way, technology may offer a means for interrupting existing power structures and relationships (Perrotta & Evans, 2013). Murthy, Iyer, & Warriem (2015) found in research on a large-scale faculty development program that a feature of the program responsible for its success "was the emphasis on practice and reflection, which have been recommended to scaffold teachers' learning in systemic plans for ICT integration" (p. 26). Fishman (2014), who has made many contributions to the study of the implementation problem has stated that,

"A key, but often unasked question, is who gets to be involved in the process of developing educational programs, interventions, or materials?" (p. 116).

He continues,

"Having students as collaborators or participants early in the design process may help developers understand where these problems will arise in order to develop, with input from students, plans for introducing innovations in ways that will be accepted and help move students, as a whole, towards acceptance and use of the intervention" (p. 117).

Chickering and Gamson (1987) formulated seven principles for using technology to enhance the quality of undergraduate education:

(1) Encourage student-staff contact using communication technologies;

(2) Encourage cooperation among students through web-based collaborative tools;

(3) Encourage active learning through simulation tools;

(4) Give prompt feedback, and monitor the diverse forms of electronic presentations created by students;

(5) Emphasize time on task by enabling staff and students to work when and where they want;

(6) Communicate high expectations, and enable peer evaluation through criteria articulated by the teacher or collaboratively generated by students; and

(7) Respect diverse talents and ways of learning by

providing opportunities for diverse learning styles, and enabling self-reflection and self-evaluation.

Researchers have found that technology-rich innovations in education are prone to many implementation problems. They often suffer from insufficient training efforts for teachers who are expected to implement the innovations (Armstrong & Casement, 2000; Barsauskas, 1998; Franklin, Turner, Kariuki, & Duran, 2001). Hasselbring, et al., 2000; Shelly, et al., 2002; Smerdon, et al., 2000). Many teachers also complain that they simply do not have enough time to do what is required of technology-rich innovations (Armstrong & Casement, 2000; Franklin, et al., 2001; Hasselbring, et al., 2000; NetDay, 2001; 2004; Shelly, Cashman, & Gunter, 2002; Smerdon, et al., 2000).

3. Objective

To better understand the issues related to the implementation of technology-rich innovations, two studies were conducted examining the implementation of a technology-rich innovation called Quest Atlantis (QA) (http://www.questatlantis.org/). In this innovation, a 3D online virtual environment is used to frame educational activities called "Quests" and "Unit Plans." QA was used in elementary schools in the United States, Australia, Denmark, China, Singapore, and Malaysia. This innovation made use of a Multi-User Virtual Environment (MUVE) as part of a computer-based learning tool utilizing "through the window" virtual reality (McLellan, 1996). Students used a computer interface that displays a window through which they manipulated a virtual instantiation of themselves. They manipulated this avatar within a 3-D virtual world in a manner common in contemporary commercial video games such as World of Warcraft (Thomas, Tuzun, & Barab, 2009; Thomas, Ge, & Greene, 2011). QA was a program for elementary school children and focused on learning in a video game like environment. Similar to a video game, the project was grounded in a robust back-story that underpinned its action and situated learning activities. The project made use of a multi-user virtual environment and an elaborate back-story to situate learning activities. The program was first designed at a local Boys & Girls Club in Indiana and then was implemented in schools throughout the country and was used in Australia, China, Denmark, Malaysia, Singapore, and South Korea. However, others who have dealt with this problem have considered that innovations should be flexible enough to deal with inevitable changes that take place in the real world. "When the QA project began, we engaged in what we called critical design ethnography. This was a long period of ethnographic study of the context of implementation at a local Boys and Girls Club" (Barab, Thomas, Dodge, Newell, & Squire, 2004). "Later, I found that teachers choose to implement QA based on its adherence to what they were already doing" (Thomas, et al., 2009). "Later, we implemented in other contexts in other countries" (Kim & Thomas, 2015). As of the time of this writing, the Quest Atlantis project is no longer available; however, the program Quest to Teach is a spinoff of the project that focuses on teacher training for the implementation of technology-rich innovations. Research on the implementation of QA was so important for two reasons: (a) it was a technology-rich innovation that was designed with flexible adaptivity in mind, (b) it was designed to be a broad scale program, and (c) this author was involved with the project as researcher and designer and design-based research was used throughout the lifetime of the innovation.

4. Design-Based Research

Exploring the implementation of a program like QA requires careful attention to what actually happens during both the design and implementation of the technology-rich innovation. Design-based research involves being situated in a real education context, focusing on the design and testing of a significant intervention (Amiel & Reeves, 2008). Design-based research is collaborative and makes use of mixed methods. It involves multiple iterations and collaborative partnerships between researchers and practitioners (Anderson & Shattuck, 2012). Design-based research studies, also called design experiments, are an effective means for conducting research on learning and design simultaneously in authentic learning environments (Brown, 1992; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). According to Amiel and Reeves (2008), the development of design principles should undergo a series of testing and refinement cycles:

"Data is collected systematically in order to re-define the

problems, possible solutions, and the principles that might best address them. As data is re-examined and reflected upon, new designs are created and implemented, producing a continuous cycle of design-reflection-design. The outcomes of design-based research are a set of design principles or guidelines derived empirically and richly described, which can be implemented by others interested in studying similar settings and concerns" (p. 35).

Conducting design-based research may help us to understand the implementation of technology-rich innovations so that we learn to negotiate the challenges of implementing this sort of innovation in schools with teachers and children from diverse communities and contexts. It may help us understand what sorts of innovation adaptations occur in implementation, why teachers and students adopt and/or resist this sort of program, and what the core challenges associated with implementing a technology-rich innovation are. It may also help us to understand mutual adaptation and how flexibly adaptive design may give us more tools for implementing such innovations. Finally, it may help us to understand the central concerns of those people closely involved with the implementation of technology-rich innovations in public schools. Designed based research may help us implement technology rich innovations and practices.

5. Case Study - Methodology

5.1 Study 1

The first study examined the implementation from the standpoint of four cases of teachers who chose to implement QA. The Case Study research questions were:

1. Why do teachers choose to implement Quest Atlantis?
2. What are the core challenges and tensions of implementing Quest Atlantis in each classroom and what are the cross-classroom themes?
3. What supports are necessary to successfully implement Quest Atlantis in multiple classrooms?
4. In what ways does Quest Atlantis adapt to local context(s) of implementation?

Roughly 250 single-spaced pages of text were employed for analysis. This included interviews with teachers, students, and school administrators involved with the project. The interviews were transcribed and coded using the qualitative research software package QSR N-Vivo. Open coding in the grounded theory tradition was completed by this author and another researcher (Glaser & Strauss, 1967; Glaser, 1978; 1998). Patterns were then noted, and themes were quantified using N-Vivo. Online portfolios of student work, activity logs of QA teachers and students, and field notes of researchers affiliated with the project were also collected and analyzed (Erlandson, Harris, Skipper, & Allen, 1993).

The textual data were coded line by line. The coding and categorization of codes were accomplished with the use of the qualitative research software package QSR N-Vivo. A total of 494,079 characters and 4,956 paragraphs were coded. The open coding led to the emergence of 320 unique, open codes. By continually comparing and reexamining the codes, the associated data, and our understanding of previous research, these 320 codes were eventually sorted into 16 categories as two researchers worked at capturing as much of data as possible (Thomas, 2004).

Counting the characters and paragraphs coded allowed the researcher to be able to get a sense of how much of the textual data buttressed the codes. In other words, it allowed for an explanation of "how much stuff is coded in these ways." This was later used to support the contentions made with respect to findings. The QSR N-Vivo software provided these counts of the coded characters and paragraphs. The researcher then used MS Excel to create tables of the percentages of the coded data the individual codes represented. This allowed for the ranking of codes with respect to both character percentage as well as paragraph percentage. Because the character percentages and paragraph percentages were different, the two numbers were averaged to account for the difference between character weight and paragraph weight. This was treated in this study as "character paragraph mean weight."

The quantification of textual data is often referred to in the tradition of qualitative data analysis as 'content analysis.' In classic grounded theory, the methodological details are often not reported as they serve the emergence of concepts. However, the initial analysis of this data was not with grounded theory, and so is included here.

5.1.1 Study 1 – Findings

Teachers chose to implement the innovation because of its alignment with their pre-existing curricular work. Specifically, they used it to support (a) higher level thinking and (b) Limited English Proficient (LEP) and special needs students. They also used it for the (c) empowerment of the children, and (d) because of the inclusion of the QA Social Commitments. This research found that QA was flexibly adaptive, and confirmed the need for innovations to have the "grass roots" and top-down support called for by researchers. Another finding was that QA (and perhaps all technology–rich innovations) implementation is context dependent.

The implementation of QA was also buttressed strongly by the students' enthusiasm for it and their eagerness to engage QA in their own time. It became clear that students enjoyed it as a game, despite QA's status as a school activity. The affordance of the interactive online 3D space allowed Questers to assist one another, to help with online building, to share, to interact socially, and to cooperate with people anywhere in the world.

Finally, the study suggested that our understanding of what it means to "support" teachers during technology-rich innovation implementation should be expanded. This deeper view should consider the need to emotionally support the teachers and not simply focus on the use of the computer technologies. Finally, it was discovered that security concerns had to be dealt with in a nuanced fashion that would address parental concerns without canceling the whole implementation of the innovation.

It should be noted that these findings, while grounded in the data, did not emerge in a fashion consistent with the grounded theory approach. This led to a refocus and reframing of the original research questions, a rethinking of the data, and a re-analysis of the data utilizing grounded theory methodology. This recoding and memoing of the original data revealed a core category of nuancing, as well as several new processes and sub-processes at work in the implementation of this technology-rich innovation. Nuancing may be defined as the process that occurs when instructional designers continually make changes to the design to fit the context of its implementation. What is important in this definition is that the changes occur continually and that the designers intentionally do them. It is an instructional design theory.

5.2 Study 2

In taking a grounded theory approach to re-analysis, Glaser, the co-founder of grounded theory, suggested reframing the four original research questions. Instead of an emphasis on why and what, the questions should focus on how. This reformulation allows a focus on the Basic Social Processes (BSPs) that may be at work in the implementation of technology-rich innovations in public schools (Glaser, 1978). Instead of asking why teachers choose to implement, we should ask how the implementation occurs. By asking how, we could illuminate the sub-processes of nuancing theory. Instead of asking what the core challenges were, the focus should be on how problems were solved. Instead of focusing on what supports might be necessary for the successful implementation of QA, the focus should be on how the support happened. Instead of focusing on the ways QA adapted, we should focus on how we should adapt technology-rich innovations to school contexts. The reformulations of the original research questions are in italics after the original questions as shown in Figure 6.

5.2.1 Study 2– Procedures

Grounded theory, the methodology guiding the research method in this study is most suitable for this type of study because it allows the researcher to conceptualize the

Original Research Question	Modified Research Question
Why do teachers choose to implement Quest Atlantis?	*How was Quest Atlantis implemented?*
What are the core challenges and tensions of implementing Quest Atlantis in each classroom and what are the cross-classroom themes?	*How were problems solved?*
What supports are necessary to successfully implement Quest Atlantis in multiple classrooms?	*How did support happen?*
In what ways does Quest Atlantis adapt to local context(s) of implementation?	*How do we adapt technology-rich innovations?*

Figure 6. Original Research Question vs. Modified Research Question

readings of the social studies textbooks leading to a theory about basic social processes within the reading. Primarily a process whose main goal is to generate theory, grounded theory requires the researcher to approach the study without a preexisting theoretical framework or coding scheme. By doing so, the researcher is able to remain open to what may be "going on" in the data and may maintain a certain theoretical sensitivity which can lead to emergence (Glaser, 1978; 1998). The first step in grounded theory is to enter the substantive field or area of interest of the research without knowing the problem (Glaser & Strauss, 1967). This requires the researcher to temporarily suspend knowledge of the literature and experience in this field. Not knowing applies to both the descriptive level and the conceptual level. Preconceiving what data will be used for a study severely restricts the generative aspect of the study and consequently the theory. Consequently, one of the basic tenets of grounded theory is that "all is data."

The theory emerges from the data as the collected data is coded, memos are written, and data and memos are sorted and resorted until the emergence of a core variable is discovered. This core variable or core category is continually compared to other categories and with indicators in the data until saturation is achieved. This means that the core category accounts for all or almost all the occurrences in the data. This constant comparison serves as an ongoing check of the researchers' tentative assertions and as a refinement of the theoretical assertions that will be made.

Grounded theory is based on a third level conceptual analysis. The first level is the data. The second level perspective is the conceptualization of the data into categories and their properties. The third level is the overall integration through sorting in a theory (Glaser, 1978). The theory emerges from the data as the collected data is coded, memos are written, data and memos are sorted and resorted until the emergence of core processes, and the sorting of these processes into a theoretical framework.

Another reason for using this methodology for this study is that grounded theory is a tool that may be used to understand the action in a substantive area from the point of view of the actors involved. This understanding revolves around the main concern of the participants whose behavior continually resolves their concern. Their continual resolving is the core variable. Thus, the goal for research using grounded theory is to discover the core variable as it resolves the main concern. In this way, grounded theory was used as an inductive approach that calls for emphasis on the experience of the participants.

5.2.2 Study 2– Findings

Results of the second study gave rise to an integrated set of patterns referred to henceforth as Nuancing Theory.

6. Results and Discussion

6.1 Nuancing Theory

This is a theory of Nuancing a technology-rich innovation as a way to deal with issues related to fidelity. All of these patterns took place in what we, as designers, did in the design, development, and implementation of the Quest Atlantis technology-rich innovation. The components of Nuancing theory are offered below. Each is a process and is named with a gerund as suggested by Glaser (1978).

6.2 Catnipping

The first component of nuancing theory answers the question: "How was QA implemented?" and is the basic social process captured by the term catnipping. The concept of catnipping is characterized by the intentional actions of the designers of the technology-rich innovation to make the innovation irresistible to would-be implementers. Like catnip, the innovation is designed to intoxicate the users and to make it irresistible. While those who work in other areas, such as business, politics, and so forth also seek to catnip. The success of such catnipping is not known until the time of implementation. History is replete with stories of products that seemed irresistible on paper, but fell flat when realized. Richard Dawkins, the noted biologist, refers to the notion of memes, which are, simply put, ideas. Like their biological counterpart, the gene, memes may or may not enjoy replication or dissemination. Dawkins even jokes that his notion of a meme is itself a good meme because it is now referred to widely in literature and in pop culture literally. However, Dawkins is also a proponent of atheism, which he is the first to admit is a much less powerful meme than the idea that there is a God. From this perspective, religious ideas could be considered catnip with this affordance of irresistibility (Dawkins, 1976).

Catnipping was discovered to contain several sub-processes conceptualized as (a) hipping, (b) cartooning, (c) cyberizing, and (d) hooking up. Below, each sub-process is explored within the context of QA specifically and technology-rich innovations more generally.

6.2.1 Hipping

The first sub-process, hipping, is the process of hyping technology-rich innovations to make users feel that using the innovation is "cool" or "hip," and that not using it is somehow primitive, old-fashioned and out of step with current thinking. Failing to use a technology rich innovation that has been "hipped" is then positioned as inherently backward. In the implementation of QA, specific design elements were included which focused on making the innovation hip, as identified by previous ethnographic research. One such method built upon the existing popularity of trading cards, comic books, and videos through the creation of such multimedia that aligned specifically with the QA background story. The principal of the school was very keen to be seen as an administrator who was up-to-date and progressive, and achieved this goal by presenting QA as something up-to-date. This has been referred to as the creepy treehouse. By being progressive and new, we were able to hip the innovation both to the principal and the students.

Many researchers have complained that there was a certain element of the unethical in hipping. However, QA is only one of a myriad of technology-rich innovations that have been sold to schools by way of hipping. Educational television and, before that, educational radio, were heralded at the times of their initiation as being the great new thing, the panacea of education. Film strips, films, and many other audio visual devices have been sold to schools. However, over time, it has been observed that the culture of school has proved intransigent. In short, the history of technology rich innovations is one of hipping the innovations while ignoring consequences as well as the overlookable, but very genuine problem of ineffectiveness. As Cuban (1986) has pointed out, many of these technology-rich innovations have been oversold and underused.

6.2.2 Cartooning

Another sub-process that underpins the larger process of catnipping is cartooning. Cartooning is the process of preparing a technology-rich innovation for children by using low fidelity images with excessive use of primary colors, high color contrast, and the exaggeration of certain features. Cartooning is based on the belief that the graphics children find attractive are the graphics of cartoons. The QA logos, trading cards, comic books, and other ancillary materials implicitly made use of the cartooning concept, although this process was never articulated as such. Instead, the explicit concern was with making everything "age appropriate" or "appropriate for kids." Here is a chart of the data that informed each part of the study. This study used the chats as well as the interviews and the observational notes.

6.2.3 Cyberizing

Another sub-process that underpins the basic social process of catnipping is cyberizing. Cyberizing is a process through which data becomes digital, making something shareable, replicable, sortable, storable, and countable. Digital information is easy to share because it may be transmitted electronically without concern for time and space, and can be instantaneously copied. Digital information is also easy to sort and indeed, databases sort through massive amounts of data simply by tagging parts of the data with any given characteristics, the most ubiquitous of which may be keyword searches. Digital information is also easily stored because instead of being warehoused like print based materials, such as books in libraries, digital information is stored electronically by various means. Many researchers in the library and information sciences have expressed concerns about this trend, arguing that digital retrieval systems have been rapidly changing, thus, data stored using older retrieval systems such as microfiche may not keep up with modern retrieval systems such as keyword searches and web-based format. Digital information is also rapidly countable by computers, regardless of what that information consists of. And so part of the process of catnipping QA involved the digitization process referred to here as cyberizing. Indeed, cyberizing helped to catnip QA through hipping as well, since making things digital is itself often seen as cool, hip, new, and therefore inherently desirable.

6.2.4 Hooking up

The final process underpinning catnipping is "hooking up." There are a few exceptional people in the world who are capable of starting "epidemics" where a very small number of well-placed people accomplish a considerable amount of work. A critical factor in such an epidemic is the level of charm and persuasiveness possessed by the messenger. In this case, the messenger for QA was the PI of the research project, who managed to convince a former student of the value of the project and thus opened the door to the entire school. Becoming "hooked up" in this fashion was as key as any of the other previously mentioned processes in supporting the implementation of QA. Once some teachers implemented the innovation, it was easier for others to accept it, which aligns with the idea of early adopters and opinion leaders (Rogers, 1995). Gladwell (2002) in his book, The Tipping Point, refers to connectors who are people with a special gift for spreading messages. These people are people specialists. They are able to occupy multiple subcultures and niches. He also refers to Mavens, people who accumulate knowledge and serve their own emotional needs by solving other people's problems. Once mavens figure out how to get a great deal, they want you to know about it too. Another type of people identified by Gladwell is Sales People. These people have the skills to persuade others who are unconvinced of what they're hearing. They're able to draw others into their own rhythms and dictate the terms of the interactions. The QA messenger was particularly persuasive and this was a major factor in the implementation of the innovation.

6.3 Adapting

The second reframed research question involved the ongoing problem solving strategies during the implementation of QA. As QA was not designed to stand well on its own, it was instructive to look at how problems were solved. The findings indicated that QA was highly context-dependent and that implementation problems were solved adaptively. Flexible adaptivity involves treating users as direct problem solvers, redesigners and builders. A specific example highlights the inter-activity and adaptability of the online 3D space of QA, which allowed children using QA to assist one another, to work together in changing the 3D environment by allowing them to design teleportation devices, and to share files and personal information. The very design of QA supported adaptivity by supporting social interaction and even international cooperation between teachers and students.

6.4 Supporting

The third reframed research question asked, "How did support happen?" during implementation process of QA. Analysis indicated that QA required complex and adaptive support that balanced between support craving and ownership killing. QA requires that teachers feel empowered and, particularly, trained to solve everyday technical issues that come up whenever people use computers. The concept of support craving highlights the need for the support to be ongoing, and in this case, such support required a full-time employee. Similarly, other technology-rich innovations that involve support craving may experience difficulties with independent implementation, or great monetary expense providing needed support.

Another problem with a support craving innovation is that offering teachers so much support has the unintentional effect of marginalizing their ownership over the innovation as well as their work in the classroom, which leads to the concept of ownership killing. Many teachers often feel disempowered by technology when computer literacy is not part of their skill set, which is compounded by two other common co-occurrences. I noted that this occurred when a teacher asked me "What about a pencil?" The first is the often presence of children who are far more adept in the use of computers than their teachers are. While such a familiarity serves to empower the students, the teacher simultaneously gets the sense of losing control as the reservoir of expertise becomes non-traditionally located within the students. The second common occurrence is the emergence of pressure from school administrators, parents, society and, indeed, advertisers to be "hip" to technology in a classroom. Too often, the benefits of technology in the classroom are treated as self-apparent, with a socially uncritical acquiescence with respect to its implementation in school.

In short, support has to be just in time, but must also be just the right kind of support. Specifically, the more complex the innovation, the more complex and robust the support must be.

6.5 Agenda Aligning

The final reframed research question was focused on revealing how to adopt technology rich innovations. This is accomplished through adapting, as mentioned earlier, as well as through agenda aligning. Here the designers must honestly ask themselves, “Is our primary goal teaching, implementing, research, or looking cool?” These are all potentially conflicting agendas possessed by designers, teachers, administrators, children and others involved in implementation. It would be a mistake to assume that agendas are ever completely explicit or uncomplicated, or that they do not overlap or evolve over time. Despite the complexity of defining agendas, establishing a common purpose is an essential aspect of nuancing for the purpose of implementing technology rich innovations in schools. Part of agenda aligning for QA was cloaking learning as a game in order to make learning fun. Such a strategy served as an attempt to align an educator's agenda with a young child's agenda. Part of agenda aligning here is also the reformer's tension between newness and adoptability. If the reformer attempts to make a change that is too different from what preceded it, then adoption is unlikely to occur. Thus the reformer and the conservative might strive to balance or agenda align the new with the old.

7. Recommendation

In summary, by reframing the research questions that were used in a qualitative cross case analysis that examined the implementation of QA in different elementary school classrooms, the conceptual core category of nuancing was discovered. Nuancing is the process of implementing technology rich innovations in schools, and is composed of four subprocesses: (a) catnipping; (b) supporting; (c) adapting; and (d) agenda aligning. The first, catnipping, is in turn composed of hipping, cartooning, cyberizing, play grounding, and hooking up. The second, supporting, involves the notion that complex innovations require multifaceted and adaptive support that manages the tension between support craving and ownership killing. Third, the sub-process of adapting involves managing flexible adaptivity, honoring users as redesigners and treating users as both builders and direct problem solvers. Finally, agenda aligning involves managing the reformer's tension of newness and adaptability by making explicit the intricate and overlapping agendas of all parties involved.

8. Implications

Nuancing theory informs the field of instructional design by highlighting processes that require design allowances and providing a blueprint for those wishing to implement and scale up their technology rich innovations. However, the theory also warns that implementation and design are inherently complex social processes, and that the thorny nature of negotiating these processes may be inevitable.

Conclusion

Reframing a study that was not originally conceived as a grounded theory study involves the development of theoretical sensitivity (Glaser, 1978). It involves recoding data that may already have been coded and recoded numerous times and in different ways. Glaser warns that preexisting baskets or receptacles in which to parse out bits of data should be shunned in favor of emergence, and that categories must earn their way into the theory (Glaser, 1998). When reframing a study that has already been completed, it may be difficult to see the data anew. However, grounding the study was an exciting and an empowering process that made the initial study more relevant. Particularly useful was memoing, which is an essential process in grounded theory that is commonly overlooked by qualitative methodologists. In this study, a lack of memoing in the collection phase was a major weakness, but after reframing the research questions and returning to the data and the initial data driven findings, memoing allowed for the emergence of concepts that seemed obvious in hindsight, but were initially elusive. It is hoped that this article may serve not only as a vehicle for the proposal of Nuancing Theory, but also as an example of how an “ungrounded” dissertation study may be subsequently grounded by reframing the research questions, consulting experienced grounded theory researchers and applying classic grounded theory methods.

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