

Complexity in an Educational Technology Transformation from Proprietary to Free/Libre  
Open Source Software: A Case Study

by

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MA, Royal Roads University, 1996  
B.Ed., University of Victoria, 1990

A Dissertation Submitted in Partial Fulfillment  
of the Requirements for the Degree of

Doctor of Philosophy

in the Department of Curriculum and Instruction

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University of Victoria

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## **Supervisory Committee**

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Dr. James Nahachewsky (Curriculum and Instruction)  
**Departmental Member**

Dr. Tim Hopper (School of Exercise Science, Physical and Health Education)  
**Outside Member**

## Abstract

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Information and communication technologies (ICT) are having a rapid and increasing impact on all K-12 schools as school districts attempt, in a myriad of ways, to keep pace with the technological changes taking place in society. Unfortunately, this impact is increasingly a financial one as financial challenges continue to figure among the most extensive barriers to ICT use (Plante & Beattie, 2004). This research explores ICT options that are cost effective to our educational institutions and our communities while maintaining high functioning and sustainable technology for students and educators. Low-cost alternative technologies such as Free/Libre Open Source Software (FLOSS) and cloud computing lessen the socio-economic divide between students, encourage the sharing of technological advancements and collaboration and allow teachers to freely and legally give their students access to software necessary for success. In addition to the potential benefits of this technology's use in an educational setting, this research also addresses the pragmatic aspects of introducing these tools district-wide. Complexity theory is utilized to lend an understanding of how to look at technological changes within the context of society as a whole, within enabling constraints that create the conditions for the emergence of new patterns of teacher, student, task and content interactions. This complexity frame informs themes in the study such as: (1) the

importance of forward-thinking technology from recursive feedback loops on decision-making and planning in order to “keep up” with technological changes outside of school, (2) the critical impact educational leaders have on the change environment when both introducing these technologies into a school district and providing enabling conditions so that new ways of teaching and learning with technology can emerge and (3) the effect changing technological systems and support infrastructures have on enabling new teaching and learning processes.

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## **Dedication**

To: Three boys and a girl.

## Chapter 1

Information and communication technologies (ICT) are having a rapid and increasing impact on all educational institutions as school districts attempt, in a myriad of ways, to keep pace with the technological changes taking place in society. Unfortunately, this impact is increasingly a financial one as financial challenges continue to figure among the most extensive barriers to ICT use (Plante & Beattie, 2004). This research explores ICT options that are cost effective to our educational institutions and our communities while maintaining high functioning and sustainable technology for students and educators. Low-cost alternative technologies such as Free/Libre open Source Software (FLOSS) and cloud computing, lessen the socio-economic divide between students, encourage the sharing of technological advancements and collaboration and allow teachers to freely and legally give their students access to software necessary for success. In addition to the potential benefits of this technology's use in an educational setting, this research also addresses the pragmatic aspects of introducing these tools district-wide. Complexity theory is utilized to lend an understanding to themes such as: (a) the importance of forward-thinking technology decision-making and planning in order to "keep up" with technological changes outside of school, (b) the critical impact educational leaders have on the change process when both introducing these technologies into a school district and providing enabling conditions so that new ways of teaching and learning with technology can emerge and (c) the effect changing technological systems and supporting enabling infrastructures have on teaching and learning.

## **Context**

### **Technology – Early exposure.**

My first exposure to personal computing was in the form of a TRS80, a computer made by Tandy in the late 1970's and early 80's. It sported a black and white screen and a full keyboard, but no disk drives. The TRS80's RAM was 4KB, in comparison; today's computers have over 2 million KB of RAM. The computer did not come with any software, and would do little more than show a cursor without software, so my brother and I spent many long hours in the dark basement typing pages of code that we copied from a magazine into the computer and then saving the program onto a borrowed cassette tape in an old cassette recorder.

Towards the mid 1980's my high school was running Apple II computers in a newly established computer lab. Though not yet utilizing mice, these more advanced machines sported a floppy disk drive, eliminating the need for tapes, and a small colour screen. As there was no productivity software (i.e. Word or PowerPoint) or Internet, students obtained technological success by typing the code required to make a colour 3-D cube rotate on that small screen. The lab also had a dot-matrix printer, popular for making banners with continuous paper. The banner in the lab read, "GIGO – Garbage In, Garbage Out" referring to the fact that computers do not discriminate and will attempt to process both correct and error-ridden code.

During college and university I supported myself by joining the Canadian military as a member of the Canadian Forces Communication Command. I enrolled during my last few weeks of high school and then completed both basic training and trades training - as a Radio-Teletype Operator (RTOP) - over my first summer and before entering

college. I worked at my unit – 741 (Victoria) Communication Squadron - both full time and part-time through university and for several years thereafter as teaching positions in my home town of Victoria, British Columbia were very scarce following massive teacher lay-offs in 1992. My experiences with 741 Communication Squadron gave me my first exposure to “useful” technology, not merely games or shapes on a screen. A world away from typing code in my parents’ basement, military technology was used to accomplish operational tasks. The teletype machine could send encrypted messages across the country and around the world. HF radios could bounce voice signals off the atmosphere to communicate almost as far and, the crowning glory, our precious suitcase-sized satellite phone cost several dollars a minute to use, but could make a phone call without a phone line! It was during these years that I began to develop my personal beliefs pertaining to technology. I came to believe that technology should be utilized as a tool to improve some aspect of our lives, to better our world or ourselves and that technology for the sake of technology, or a toy without any real purpose or improvement is simply a waste of money, time and effort.

### **Beginning teaching.**

I earned my first continuing contract (permanent) teaching position based on the knowledge and experiences I had gleaned from the Canadian Forces. The school principal was looking for someone able to teach students how to use the new Microsoft Windows 95 and Office software. Having used this software in the military, I felt confident I could use it with elementary students. The students were eager to learn and easy to teach, however I questioned why I taught productivity software when the students were not able to actually produce anything (other than on their screen) because the

computers were not attached to a printer or to the Internet. Students' work could only be saved to floppy disks, not shared or printed. That fall, with the help of some military friends, I rectified this productivity issue by setting set up a school printing network. Utilizing dozens of handmade computer cables and a single inkjet printer, students were afforded the opportunity to print their typed assignments and art work. Although the Internet was still not available in elementary schools, this would change in less than two years.

During the summer of 2001, a new computer lab was built, complete with Internet connections, outside windows that actually opened and 32 networked computers connected to both a server and a printer. Although I don't remember the exact cost, I do remember being staggered when I learned the price of this resource. The price the school was willing to pay was shocking to me because this was a school in a low economic area of British Columbia and one that had limited educational resources and mostly empty shelves in the school's book room. Teachers bought, borrowed or made most of their teaching materials as there were very few provided by the school. I remember being torn between the thrill of having the opportunity to work in such a leading-edge computer lab and the concern for the way in which the school's funding was being allocated. It certainly occurred to me that students and teachers were being denied educational resources such as textbooks in lieu of a showcase computer lab. Although the computer lab allowed the children to access literacy, numeracy, science, socials studies and other resources never available to them before on a computer, they were only scheduled for one or two blocks in the lab a week, so the utilization of textbooks was still a large and necessary part of the curriculum.

**Recent teaching.**

Over the next twelve years I worked as a classroom and computer lab teacher in K-7 public schools. During this time, I became even more aware of both the financial burden technology placed on a school and the difficult financial decisions my school technology team needed to make to keep our lab computer operational. The leading edge computer lab that was installed just half a dozen years earlier was now ageing and unsustainable, the software was becoming obsolete and systems were failing. The upkeep decisions were financial, often between upgrading existing software and purchasing newer hardware. It was not financially possible to do both.

Schools' technological and financial problems continue to this day, especially given Microsoft's recent announcement: Microsoft has announced that the operating system Windows XP will not be supported after April 8<sup>th</sup>, 2014. This will put enormous pressure on schools and districts to do exactly what they can't afford to do –to buy both new hardware and software. They will need to do this because if schools keep running Windows XP, without Microsoft's support, the lack of Microsoft security updates puts all of the school computers at risk for viruses and other security issues. Upgrading to Windows 7 or 8 however, will require purchasing new machines as most school computers are too old to run Windows 7. On last count, my school had 250 student computers: 32 were in the computer lab and the rest were spread throughout the library, resource rooms and 22 classrooms. A conservative estimate of \$800 per machine and its new software multiplied by 250 machines in our school alone adds up to \$160,000. This outlay is simply not feasible, in spite of this school being in a high economic area. Other schools will certainly be facing similar dilemmas as Plante and Beattie (2004) discovered

that, “Only 23% of the elementary and secondary schools in Canada had the majority of their computers running on the most recent operating systems” (p. 12).

The financial concerns I described above have also been expressed by teachers and parents around my province. The province of British Columbia has recently asked for feedback on their new set of digital literacy standards for students. This website reads, “One of the things we’ve been working on lately is a set of digital literacy standards for students. These standards identify the skills and knowledge students need to be successful in our increasingly digital world” (Province of British Columbia, 2012). Unfortunately, nowhere in the document does the government propose how schools will *afford* the technology to ensure these standards are met. One of the concerns voiced on the site’s comment section is related to the reliance on Internet-based resources. One parent was concerned with the lack of a reliable Internet connection in her child’s urban elementary school. The parent wrote:

The children experience difficulty connecting to the Internet, or if connected, lose the connection and have to log on again and they also experience long download times. The infrastructure is just not there to support what the school has now let alone adding more. (Bev, 2012, para. 3)

As many of the British Columbia Government’s new digital literacy standards require Internet access, slow and unreliable Internet access would make meeting the standards difficult, if not impossible. A teacher wrote on this same digital literacy comment forum and described the both ageing computers in his school and the slow Internet speed. He voiced his concern that although the proposed standards look great, he would not be able

to meet the standards because his students did not have access to reliable technology. He explained:

We have access to one open computer lab with the oldest computers in the school (take about 5 minutes to start up). The Internet is so slow in the school ...that I can't even stream a video during class.... [and] it takes minutes for a webpage to load on library computers.(Anonymous, 21 October 2012, para. 28)

A high school teacher also commented on her inability to meet these standards due to the lack of access to computers capable of running the productivity software or to high speed Internet. She explained:

I have just looked at the standards for the grade levels I teach (our senior students) and my jaw dropped. These kids do not have the access to computers that can use MS Publisher without crashing. They have to wait minutes for search results and we are seriously considering asking them to become digitally literate? (Maryaf, 2012, para. 29)

Although the first three comments received no feedback whatsoever from the BC Ministry of Education, a fourth comment, along similar lines, did receive a response. The question posed by a teacher read, "How can we expect these standards to be practiced, demonstrated and assessed? There is a severe lack of access to devices which are suitable for creating digital content (i.e. computers)" (Shmish, 2012, para.34). The response, from Tim Winkelmanns, the lead for e-learning and graduation in the BC Ministry of Education, was to inform readers that the responsibility for providing adequate technology to meet the province's new standards was that of school districts. He wrote, "Regarding your first question, what we see in the province is that when districts make this a priority, they find

ways to invest” (Winkelmans, 2012, para.36). I believe that the BC Government’s top-down act of adding new digital learning standards without providing any enabling infrastructures such as training and the financial support for them will ensure that they are not universally met and that new digital literacy standards will put even greater financial pressure on school districts already struggling to balance reduced educational budgets.

In addition to my aforementioned financial concerns regarding how schools and districts would be able to afford the technology necessary to meet student and teacher needs as well as the new BC Digital Literacy Standards, I had also begun to question the moral and ethical aspects of teaching children how to use proprietary software, such as Microsoft Office or Adobe Photoshop, in a public school. As a technology teacher, I had the opportunity to have an enormous influence on my students’ at-home use of technology (I know this based on the number of times a day a child asked me if he or she can access a certain activity from home). Because of this influence, I believed it was morally and ethically irresponsible to teach my students how to use software that their parents felt they must then purchase. Not only did I not want to put yet another financial burden on parents, I also had no wish to be a salesperson for proprietary companies. It bothered me that I was put in the position of “selling” software to children. I was certainly a salesperson, for I introduced the children to certain brands of software, I taught them how to use it and I gave projects utilizing it. Then, these same children might ask their parents to buy this software so that they could use it at home, thus making me appear to be an advocate for proprietary software. As a teacher I was not comfortable with this role.

In addition to not wanting to be a salesperson for proprietary software companies, I also did not wish to be part of increasing the digital divide that exists between students who could afford to buy these new technologies for their homes and those who could not. To address my concerns regarding this situation, and after much exploration on my own, I started using free cloud-based software or Free/Libre Open Source software (FLOSS) whenever and wherever possible. The cloud-based software students utilized in my computer lab included free on-line educational resources to explore literacy and numeracy activities. Some examples of these are Rainforest Maths and Starfall – students can access these on-line activities from the computer lab, their classroom computers and from home. Students also utilized FLOSS (often run from small USB drives) to edit photos, draw, make movies, compose music, write cartoons and create stop-motion animations. Students could utilize this software at home by either downloading it for free or by bringing in a portable USB drive for me to load the software on for them. Recently, when a student asked me if they could use certain software at home, it felt “right” to be able to write down the website where they could either download the software or access it for free.

In addition to questioning the price of maintaining technological systems and the use of proprietary software in education I also questioned the large amount of educational dollars wasted on certain proprietary hardware, such as interactive whiteboards purporting to improve education through their use alone. I saw this as a grand marketing plan in which proprietary companies were convincing educators that the purchase of an expensive, flashy piece of technology alone will somehow improve education. I think that the purchase of these devices puts an incredible strain on schools’ financial resources and

does nothing to encourage innovative pedagogy – it only reinforces the top-down, teacher –in-front, and antiquated Industrial Revolution style of teaching. This hardware and software does not encourage communication, collaboration or problem solving skills needed for the success of 21<sup>st</sup> century students. The position that technology alone will not improve education is not a new one by any means. Thirty years ago, in his article, “Reconsidering Research on Learning from Media,” Richard Clark (1983) stated that, “Consistent evidence is found for the generalization that there are no learning benefits to be gained from employing any specific medium to deliver instruction” (p. 445). He described a myriad of tried and failed attempts to enhance student learning through the employment of different medium or mix of media. He articulated that no difference would be garnered from any forms of media because they are all merely different forms of vehicles to deliver instruction. He argued that these different vehicles, “...do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition” (p. 445). He also added, “...only the content of the vehicle can influence achievement” (p. 445). Clark did suggest that, “It seems not to be media but variables such as instructional methods that foster learning” (p. 449). The exact same view was re-iterated 25 years later with the following explanation:

The past half-century of research, evaluation and best practice evidence about learning from instruction has established that the choice of media does not influence learning or motivation. ... The current view that is most widely accepted in research and evaluation is that media only deliver instruction but do not influence learning. (Clark, Yates, Early & Moulton, 2008, p.2)

If 50 years of research illustrates that technology alone will not improve education, it was hard to understand and accept that thousands of dollars were being spend on yet another “stand and deliver” device. Additionally, as described by Seymour Papert (2005), the technology, if used with the same methodology, can actually make things worse. He stated:

The phrase "technology and education" usually means inventing new gadgets to teach the same old stuff in a thinly disguised version of the same old way.

Moreover, if the gadgets are computers, the same old teaching becomes incredibly more expensive and biased towards its dullest parts... (p. 353)

Although I believe Papert’s sentiments can be seen in the use of PowerPoint-based lessons and utilization of SmartBoards to deliver classes and with Clark’s that this expensive technology would not make any substantial difference to education, I still witnessed expensive technologies being purchased by my school administrator. Parents on a tour of the school were being told how wonderful it was to have SmartBoards in classrooms.

The aforementioned financial challenges to sustainable and affordable educational technology, my moral and ethical concerns regarding teaching with proprietary software and my bafflement at the purchasing of expensive hardware to support outdated pedagogy were three forces driving my decision to investigate low cost alternative technologies in education. I wondered what solutions were available to schools and districts. Did schools need to continue spending ever greater amounts of their dwindling resources on maintaining and replacing proprietary software and systems, or was there another option? Were there non-proprietary options available that would support new

ways of teaching and learning and, if so, how could they be implemented and utilized district-wide to improve education?

### **Focus**

Although I have successfully used some FLOSS in my teaching, I have always used it in a PC/ Windows environment, and in conjunction with proprietary software. Also in my teaching environment, I alone made the decision to adopt this software; it was not a district-led, nor a district supported initiative. In the case I will be studying, the entire district uses primarily FLOSS on thin-client machines (a computer without a hard drive –as all of the software needed is stored on a larger, more powerful computer called a server) that run on a FLOSS operating system called Linux. Additionally, and unlike my solitary efforts in my computer lab, the transition to this software and equipment was district-wide, district-led, district-funded and district-supported. The district also provided opportunities for training, professional development and collaboration to better utilize the technology initiatives. Based on the aforementioned frustrations I experienced in my own working conditions and the completely different approach this other district was taking, I was drawn to study this other district to satisfy both my own interest in educational technology and for this research.

### **Research Questions**

My research focused on the “how” and “why” aspects of this district-led technological implementation of FLOSS and thin client machines. As the district I worked in (and the others in my region) continued to use an outdated Windows environment on ageing machines, I wanted to know everything about this implementation and why this district chose this route. To this end, my main research questions were:

1. Why and how did the district choose to implement these changes?
2. How did the school district implement these changes?
3. How do educational stakeholders in these districts view these changes and do the changes affect teaching and learning?

**Why and how did the school district choose to implement these changes?**

I wanted to know who made this decision and what it was based on. For instance, were the reasons financial, educational, or ethical or were there other motivations? Why did this district chose a course of action completely different from all of the rest of the districts in the region and what did they hope to gain from such a radically different approach?

**How did the school district implement these changes?**

I wondered how the district approached such a massive undertaking. I thought that the logistics of replacing every machine in an entire district to be a mind-boggling task and wanted to know how it was done. In addition to the challenge of the machines themselves, how were the teachers and students affected by this change? How were employees treated during this transition? Were they left to learn the technology on their own, or was any training provided? Were educational stakeholders acknowledged as a critical component of any change, or was this something that was done *to* them?

**How do educational stakeholders in these districts view these changes and do the changes affect teaching and learning?**

In my career as a classroom and computer lab teacher, I have noticed that any changes in education are, more often than not, viewed in a negative manner because the changes often come without warning and in a top-down manner. Therefore, I was curious

about the impact of these changes on the teachers, students and staff in the district. I wondered how much resistance there was to the change of all of the hardware and software systems staff members and students were accustomed to. I also wanted to know how they viewed the change process, the support (if any) they were given during the transition and if the end result was seen as satisfactory. Lastly, as with any educational research, the impact on the students and teachers was of paramount interest to me. I wanted to know the impact that the change in technology had on teaching and learning.

In this introductory section, I described my own history both using and teaching with technology. I also presented my ethical, financial and pedagogical concerns regarding the utilization of proprietary software and hardware in education. Lastly, I introduced my case study research questions and what I hoped to learn from a district that was making drastic changes to their educational technology.

In the next section of this dissertation, my literature review covers the different types of hardware and software utilized in education. I will also take a more in-depth look at: (a) moral and ethical concerns regarding the utilization of commercial technology products in education, (b) the challenges of sustaining up-to-date technological systems in schools, (c) an exploration of how learning paradigms have changed over time and (d) how the theory of complexity will be used as a lens to understand and interpret the data from my case study.

## **Chapter 2: Literature Review**

In this literature review I commence with an overview and examples of the different types of hardware (equipment) and software (programs) utilized in the district I studied. I will also discuss some moral and ethical concerns related to the use of certain hardware and software choices in education, and the challenges to changing the software and hardware that teachers and students use. I will then present a review of how learning paradigms have changed over time and will finish with complexity. I will then examine complexity as a theory of education.

### **Overview of Information and Communication Technologies (ICT)**

The following three sections provide an introduction to the four types of hardware and software referred to throughout this dissertation. They are: Free/Libre Open Source Software (FLOSS) (such as Audacity, GIMP and LibreOffice) which is free software built by a community of users, proprietary software (such as Windows 8, Adobe PhotoShop or Microsoft Word) which is paid software and Cloud computing (such as Gmail, YouTube and Facebook) which is Internet-based computing. Lastly, I describe thin client machines which are computers without an individual hard drive to install programs or store files.

#### **Free/Libre Open Source Software (FLOSS).**

Free and Open Source Software, used in my exemplary case, are two slightly different types of software. Although both these types of software are used for free by educators, they come from two different philosophies. I think it is important to acknowledge, in this literature review, both philosophies.

The Free Software Foundation (FSF) was started by Richard Stallman. His philosophy was to give freedom to computer users by replacing proprietary software, with its restrictive licenses, with free software (Free Software Foundation, 2011). The Free Software movement focuses on moral and ethical issues relating to the freedom of users to use, study, modify and redistribute software. Stallman decreed that software should be free of charge and should allow everyone the unrestricted right to learn from it, use it, change it and distribute it. The FSF website outlines four essential freedoms that computer software users must be entitled to:

1. The freedom to run the program for any purpose.
2. The freedom to study how the program works and change the source code.
3. The freedom to redistribute exact copies of the program.
4. The freedom to distribute modified versions of the program (Free Software Foundation, 2011)

In order to preserve these freedoms, Stallman altered existing copyright rules and developed “Copyleft” (Free Software Foundation, 2011). Copyleft protects the rights of users by ensuring they can copy and change the work in perpetuity, with the caveat that all future versions of the software must also remain open and free.

Alternatively, the Open Source Initiative (OSI) advocates take a more corporate approach, focusing on the advantages of the Open Source software development method (Tong, 2004), which is a group or community working together on software development. In order to be approved and certified as open source, the OSI has criteria that must be followed. These include:

1. Free Distribution. The software can be sold or given away

2. The software must include source code.

Although the users must be able to see and modify the source code, unlike the Free Software Movement, there is no criterion that the software, and all subsequent versions of the software, be provided open and free of charge to all users.

To blend these two movements, many people have chosen to use the term FLOSS (Bacon and Dillon, 2006) for “Free/Libre and Open Source Software.” The word “Free” refers to free of charge, and “Libre”, the French word for free, refers to free as in free speech or the freedom to do as you wish. For the purposes of this literature review, the term FLOSS will be used to describe all free software that falls under the either Free Software Movement or the Open Source Initiative.

**Proprietary software.**

Proprietary software is commercial or purchased software and is the norm in most schools (Hepburn, 2005) because “Microsoft has had a near-monopoly on the software market since the release of Windows 95” (Hepburn, 2005, para 10). Some examples of proprietary software are Kidspiration, Photoshop, Microsoft Office, KidPix, and Internet Explorer. Unlike FLOSS, proprietary software does not provide the source code to users (therefore they are unable to adapt or modify it in any way) and it does not usually allow a teacher (or anyone) to freely distribute or give away copies. Although it is sometimes given away free of charge, it is most often purchased.

**Cloud computing.**

Cloud computing is Internet-based computing that has the potential to significantly reduce information and communication technology (ICT) costs in education (Sultan, 2010; Johnson, L., Levine, A., & Smith, R., 2009; Dyrli, 2009; and Hastings,

2009). Sultan (2010) described cloud computing as, “clusters of distributed computers (largely vast data centers and server farms) which provide on-demand resources and services over a networked medium (usually the Internet)” (p. 110). Students and teachers utilize Internet-based software to create, store, edit and share documents such as, documents, photos, mind maps, music, slideshows, sounds, videos, spreadsheets and many other projects (Appendix D) usually free of charge. One advantage to this form of computing is that no storage devices are needed to transport data from one computer to another. Another advantage is that the created documents are cross platform meaning a student or teacher can begin a document at home using a Macintosh, Linux or PC computer (or even their phone, IPod or tablet) and then open the same document at school using any operating system that can access the Internet. The Horizon Report by Johnson et al. (2009) described how schools are utilizing cloud computing stating:

Schools are beginning to take advantage of ready-made applications hosted on a dynamic, ever-expanding cloud that enable end users to perform tasks that have traditionally required site licensing, installation, and maintenance of individual software packages. Email, word processing, spreadsheets, presentations, collaboration, media editing, and more can all be done inside a web browser, while the software and files are housed in the cloud. (p. 20)

In an educational setting, web-based applications are an excellent alternative to proprietary software because they “offer a cost-effective solution to the problem of how to provide services, data storage, and computing power to a growing number of Internet users without investing capital in physical machines that need to be maintained and upgraded on-site” (Johnson et al., 2009, p. 19). Additionally, , “cloud-based applications

can provide students and teachers with free or low-cost alternatives to expensive, proprietary productivity tools” (Johnson et al., 2009, p. 20). Dyrli agrees with the potential savings in maintenance, labour and software stating, “In K12 education, cloud computing holds incredible promise for improving efficiency and reducing costs relating to maintenance and installation, particularly in district administrative functions. As more resources move online into the cloud, the need for constantly upgraded software, computers and local servers rapidly erodes, saving time and money” (2009, p. 33) . Hastings (2009) is also of the same mindset regarding the cost savings of cloud computing. He stated, “Applications and storage live in that ‘cloud,’ and upgrades and maintenance take place there, too. That spells potential savings in software, storage, and support costs (p. 35).

Through the utilization of cloud computing, students can not only access and edit documents from any computer running any operating system, they can also share their documents with others. This is a major advancement over desktop applications. For students, this allows easy collaboration as any number of students can edit the same document at the same time, share space on a virtual whiteboard, draw together with the same application or create a slideshow together from their home computers. This flexibility supports collaboration among students. Greenhow, Robelia and Hughes (2009) explained, “Increased cloud computing software, run over the Internet rather than locally on a user’s computer, will likely intensify the participatory and creative practices discussed” (p. 255). Lastly, unlike desktop applications which are limited to those installed on a computer, cloud-based applications give the user easy access to a myriad of

applications. Switching from one application to another can be done by simply changing websites.

The one drawback to using public cloud-based resources, such as Google Docs, is the lack of guaranteed privacy. Although users can password protect their documents, there is no guarantee that government or other agencies will not access personal files. For instance, Canadians who use Google Docs or Survey Monkey may be subject to the United States Patriot Act because their information may be stored on servers located in the United States thereby subjecting Canadians to this US act:

The Patriot Act allows for the US Government to access personal information that is held or accessible by anyone within the United States .... The information which can be collected pursuant to this court order is very broad. ... The Government can issue National Security Letters whereby they can request that personal information be disclosed to them...No court order is necessary for a National Security Letter to be issued. (University Of Alberta, 2009)

Due to this potential lack of privacy for students, teachers wishing to utilize public cloud computing resources in education may not be able to do so. Despite this potential lack of a guarantee of privacy when using free public cloud resources, cloud computing still holds promise for educators because is it possible to replicate these services on private or district-held servers, thus ensuring privacy from foreign governments for students and teachers. Therefore, the advantages to cloud computing include: the flexibility to use any platform, the lack of installed software, the accessibility to documents from any computer

or mobile device, the ability to collaborate and significant cost savings in maintenance and software.

**Thin client machines.**

Thin client machines, also known as “thin terminals” are different from desktop computers in that they do not have a hard drive to run software or store data on each individual machine. They rely on cloud computing because all of the software or files users need is stored centrally on a server. Hayes (2009) describes a thin client as a machine that,

Comprises compact processing units that depend largely on servers to perform their computational roles: so, unlike a standard PC, it manifests minimal technology at the desktop, consisting usually of just a small processing unit, input devices (keyboard, mouse), and a display. Thin-client terminal devices have no moving parts, and function primarily providing users with a connection to data and applications hosted on a server. (p. 52)

The advantage to thin client machines include a lower total cost of ownership because they: are less expensive to purchase, have a longer service life, have a reduced power consumption, require fewer maintenance hours because they are centrally managed, have improved security, have reduced space and weight requirements (meaning they are lighter and take up less room on a desk), produce less noise pollution and have an inherent theft deterrence because there is no computer to steal (Brinkley, 2010; Hayes, 2009; Martínez-Mateo, Muñoz-Hernandez & Pérez-Rey, 2010; Qin, B., Yang, M., & He, Y., 2011; Romm, 2006 and Williams, 2005). Conversely, the disadvantages of thin clients can be a reduced software compatibility because not all software will run from a

server, inflexibility in terms of the user being able to load unique software on just one machine (however, in my school and university this is no longer an option on the PC or Mac machines either) higher bandwidth requirements, reduced peripheral options if the chosen thin client machine does not have CD or USB ports, and poor multimedia performance over some networks (Brinkley, 2010; Williams, 2005).

### **Moral and Ethical Concerns Related to Software and Hardware Choices**

This section compares and contrasts literature on proprietary software and FLOSS in the moral and ethical areas of the influence the school may have over the software choices made by students and families and the appropriateness of exposing children to commercial products. This section also reviews the access students need to software in order to be successful in school and how the utilization of proprietary software may jeopardize this access and/or encourage students to illegally copy this software. Lastly, I review proprietary software and FLOSS in terms of either encouraging the censorship of information and initiatives or sharing information and working collaboratively on technological advancements.

#### **Perceived influence of software choices.**

The software choices made by a school or district do influence and effect students and families. Educators must be cognizant of this influence and effect the use of certain software has on their students and their school community. For instance, if a school chooses proprietary software, it implicitly makes that decision for its students as well because students who want to work on their school projects both at home and at school must purchase the same proprietary software used at their schools (Hepburn, 2005 and Pfaffman, 2008). Additionally, when a school chooses to use a certain brand of software

families may see this as having “the tacit endorsement of respected teachers and school officials” (Wilcox, B., Cantor, J., Dowrick, P., Kunkel, D., Linn, S., & Palmer, E., 2004, p. 6) which may, in turn, also encourage families to purchase certain brands of software. Although this influence on software choices would be the same if the school was utilizing FLOSS, the difference would be that families could obtain FLOSS free of charge.

### **Exposing children to commercial products.**

In order to encourage schools and universities to use their products, educational pricing is available (Tong, 2004). However, “it may come as a surprise to teachers that ‘Licensed for education use only’ is not altruism, it is good business sense” (Pfaffman, 2008, p. 27). As a computer teacher in an elementary school, when I used Microsoft Word (or another proprietary type of software) with a class of children, I not only exposed them to a commercial product and logos, I also taught my students how to use this proprietary product. My teaching with Microsoft Word was a very effective marketing strategy. Hepburn (2005) explains that,

The potential harm to students may be even more serious when it comes to ICT than it is when, for example, a corporate logo is displayed or advertisements are shown. When schools select commercial software packages, the students are not only exposed to the logos and products of a company, but they are also trained in how to use the software. In this sense, schools are a highly efficient marketing opportunity for software companies as they train the future users of the product while paying the company for the right to do so. (para. 13)

The above quote from Hepburn’s “Open Source Software and Schools” paper illustrates that when proprietary software is used in schools, teachers become the “unwitting sales

agents of software companies” (Pfaffman, 2008, p. 27) because students are exposed to highly effective commercial marketing. Therefore, the appropriateness of utilizing proprietary software in schools is an issue I and other educators need to seriously consider.

### **Access to educational software and tools.**

As mentioned earlier, students need access to the same software at home that they have at school. By utilizing proprietary software at school, educators may be inadvertently encouraging students to illegally copy proprietary software (Tong, 2004). This is because the licensing restrictions of proprietary products make it illegal for students to take the school software home with them to work on school work, or to take it with them when they leave a particular school, therefore students and families must choose between buying and stealing software.

In contrast to proprietary software, if a school chooses to utilize FLOSS students are able to have the same software at home and at school without having to choose between buying or stealing that software. This is because families are able to either download the software students are using or obtain a free copy from the school. Walters (2007), Pfaffman (2007) and Giza (2005) agree that this flexibility in licensing has substantial benefits for students. Pfaffman explains that, “There are dramatic advantages to arming students with tools that assure them access wherever they go” (p. 40). Giza (2005) adds that, “pupils who can afford the tools at home have a distinct advantage over pupils who cannot afford productivity and multimedia production tools” (para. 1).

### **Censorship or sharing of technological advancements.**

Another concern regarding the utilization of proprietary software I have, and is expressed in literature, is the inability of users to see or modify the source code. Although the ability to modify the source code is not a right many users would choose to exercise, it is an important right nonetheless. For those with the ability to modify the source code, they are able to change the software to meet their needs and the needs of their organization, such as adding a feature to the software so that it better meets school or district needs. They are also able to fix any “bugs” or problems with the software themselves without having to wait for the company to release a fix. Having the freedom to view and modify the source code has been compared to the freedom of free speech and to being able to look into the engine of our cars – just because we do not choose to look under the hood or alter the engine ourselves does not mean that our cars should be sold with their hoods welded shut. This lack of information sharing, especially in educational institutions, has been criticised by Tong (2004). He described his concerns in his statement, “throughout many school systems, the software in use on computers is closed and locked, making educators partners in the censorship of the foundational information of this new age” (p. 2).

In stark contrast to proprietary software, FLOSS projects are collaborative and therefore shared and worked on by many programmers around the world. Additionally, “the open philosophy of FLOSS is consistent with the sharing of knowledge and information common in academia” (BECT, 2005, p. 6). It is believed that this sharing of ideas and working together creates a better product and by sharing source code developers can build on what has already been created without having to go back and re-

invent the wheel. Eric Raymond, the founder of the Open Source movement, has been quoted throughout the world wide web and by Pan & Bonk (2007) as saying, “Given enough eyeballs, all bugs are shallow” meaning the more widely available the source code is for public testing, scrutiny, and experimentation, the more rapidly all forms of bugs, or problems with the software, will be discovered and fixed. Bacon and Dillon (2006) believe that the sharing of source code and programming ideas is far more than mere collaboration on software development, they believe that:

It is a cultural phenomenon that is underpinned by technological development with the aim of contributing to the public good. It is of relevance to our understanding of how people learn and produce knowledge, of how communities collaborate and work to solve problems, and how innovative practices emerge. (p. 7)

In this section I reviewed literature on proprietary software and FLOSS in the moral and ethical areas of the influence the school may have over the software choices made by students and families and questioned the appropriateness of teaching with commercial products. I also reviewed how the access to software students need in order to be successful in school is influenced by the type of software they use in school and how the utilization of proprietary software may encourage students to illegally copy software. Lastly, I discussed software in terms of it either encouraging censorship of ideas, as in proprietary software or encouraging collaboration and the sharing of ideas and innovations, as in FLOSS.

### **Sustainability and cost of ICT software and hardware in education**

Proprietary software and the upgrades to it are costly (Tong, 2004). Thornburg (2006) reported “It is not uncommon to find \$500 of software on each student computer. Software can now cost more than the computer it runs on” (para. 2). When this software amount is multiplied by all the computers in a public school, the costs become prohibitive (Tong, 2004). Plante & Beattie (2004) and Hepburn (2005) explained that these financial challenges figure among the most extensive barriers to ICT use as “nearly 67% of principals reported that ‘having sufficient funding for technology’ as an extensive challenge to using ICT in their school” (Plante & Beattie, 2004, p 27).

In addition to the aforementioned challenge of affording the initial purchase of software for school computers, upgrades and time spent accounting for licenses, also burdens limited school funding. Due to this expense, many schools are late in upgrading to current operating systems. In fact, “only 23% of the elementary and secondary schools in Canada had the majority of their computers running on the most recent operating systems” (Plante & Beattie, 2004, p 12).

Conversely, using FLOSS in schools reduces the financial burden on both the schools (Trotter, 2004) and the families in the school community because FLOSS is free, and FLOSS products are now available to replace almost all proprietary software (Table 1 and Appendix D) used in K-12 classrooms (Pfaffman, 2007; BECT Study, 2005; Hepburn, 2005; and Thornburg, 2006).

Although installing a low-cost alternate operating system, such as Linux, was once considered a gesture of defiance against Microsoft, “Free and Open Source has come a long way from its anti-establishment origins” (Business, 2009, para. 3). They are

now chosen not only because they are free, but also for their “better performance, reliability and security” (Tong, 2004, p. 2). In addition to the cost saving, Hepburn (2005) believes that using FLOSS in schools is also about values. He wrote “...deciding to move to [FL]OSS, comes down to schools making better decisions about spending taxpayers’ money and setting new values in place for educational ICT” (para. 33).

**Table 1 - Examples of FLOSS and Proprietary Equivalents**

<b>FLOSS</b>	<b>Proprietary</b>	<b>Function</b>
Libre Office	Microsoft Office	Documents, presentations, spread sheets
GIMP	Adobe Photoshop	Photo Editing
Firefox	Internet Explorer	Internet Browser
CMap	Kidspiration	Mind Mapping
Tux Paint	Kid Pix	Children’s drawing
Audacity	Sound Forge	Sound Editing
7-Zip	Win Zip	File Compression
Calibre	Adobe Reader	e-book organization
MuseScore	Finale NotePad	Music Composition
VLC	Windows Media Player	Music and video player
Qualyzer	NVivo	Qualitative Data Analysis
Ubuntu (Linux)	Windows 7	Operating system
Komposer	DreamWeaver	Web page editing

Pfaffman (2007) added that, “using only free software has considerable economic, technical, political, pedagogical, and moral advantages – and surprisingly few

frustrations” (p.38) and Hepburn agrees, stating FLOSS has “clear advantages over proprietary software in the areas of cost flexibility and ability to address some ethical and social issues” (Hepburn, 2005, para.32).

### **Challenges to Changing Software**

As reviewed previously, there are many articles and opinions supporting the use of FLOSS in educations. Unfortunately, I have not been able to locate any studies on how a district can successfully make the transition from proprietary software to FLOSS. This next section reviews literature on the challenges a school or district might face if they decided to transition their software from proprietary to FLOSS. These challenges are surprisingly more about educating teachers, technicians, and administrators and not about any technical difficulties with the software itself or about difficulties for students, teachers or staff. Challenges to the successful implementation of FLOSS include convincing users that there is a choice in what software they use, changing the mindshare or belief that FLOSS is illegal or inferior, understanding that significant re-training will be not required and convincing decision-makers that sticking with the status quo is not the best option.

#### **Reliance on proprietary software.**

Educators’ acceptance of proprietary software as the status quo and the perception that if we are going to use ICT, we need to learn how to use a particular product (Hepburn, 2005) is one potential barrier to the utilization of FLOSS in education. This reliance on proprietary products, user’s willingness to accept them as the status quo and their unwillingness to explore other software options has been explored by Hepburn (2005). He explained that, “Proprietary software companies do not force people to use

their software, but have nonetheless been successful in creating a monoculture in which Windows and other proprietary software appear to be the natural choice” (para. 8). He goes on to explain that, “these companies have power because the users believe that they do” (para. 8) and that maintaining their monopoly is not about software performance or price, but about the user’s belief in the product.

**Understand FLOSS is not illegal or inferior.**

A second challenge to the acceptance of FLOSS in education is the fact that many educators may not understand what FLOSS is. For instance, it may be viewed as illegal because using software without paying for it is somehow stealing or it may be viewed as inferior because it is written by “volunteers” (Pfaffman, 2007 and Thornburg, 2006). However, the facts are that “most of the programs are labours of love with global support teams that track down and fix bugs reliably” (Thornburg, 2006, para. 6) and that “...most people develop software because they enjoy it” (Pfaffman, 2007, p. 39). In response to the misconception concerning the software being written by volunteers, Pfaffman (2007) pointed out that Copernicus never performed astronomical observation and calculations professionally and Albert Einstein was working as a patent clerk when he wrote the four papers that form the foundation of modern physics.

**Realize re-training is not required.**

Another common misconception is that switching to different software will require re-training. Thornburg (2006) explained that using FLOSS products are as intuitive as using their proprietary alternatives. Any fears or concerns regarding these products will be alleviated simply by trying them. As I have used and taught with both proprietary software and FLOSS, I would liken the difference to driving a different car –

sure the buttons may be in a different place, but it has the same abilities and it gets you where you want to go! In one school the Microsoft Word logo was left in place on the computer desktop, but the icon opened a FLOSS alternative – Open Office. Users did not report any problems with the software (Walters, 2007). The British Educational Communications and Technology Agency (BECTA) study not only supports this finding, but it found that FLOSS was even easier to use than the proprietary counterparts. This study on open source software in schools stated that, “There was a perception that open source productivity software was easier or simpler to use than the non-OSS equivalents” (BECTA, 2005, p. 4).

### **Challenge the status quo.**

The desire to maintain the status quo is also a formidable challenge to anyone wishing to lead the implementation of FLOSS products in an educational setting. Teachers, administrators, students and technicians are hesitant to move away from products that they know how to use and that work. Hepburn (2006) referred to this as “mindshare” and stated that “The mindshare that MS [Microsoft] and other proprietary companies enjoy needs to be challenged” (para. 29). It may be that mindshare is one of the reasons I have most often seen FLOSS trialed in isolation. A technician may try it with one school or a teacher will try it out with one class or one lab of computers. However, in my experience, it is difficult for one teacher to utilize FLOSS with a class of students without the support of the administrators and school technician because most school computer hard drives are locked, which means no software can be loaded without the administrative password. Also, it is usually difficult for one technician to change an operating system without the approval of the district. In order to make any school or

district wide changes collaboration is required at many different levels: Teachers, technicians, principals and often district personnel and parents must not only agree that FLOSS is a viable alternative and something they want to implement, they must also work together to successfully implement the changes in their software.

In this section I reviewed literature on information and communication technologies used in education as well as the moral and ethical concerns regarding software choices and the impact these choices have on students and families. I also reviewed the challenges educational leaders may have if they decide to change from proprietary software to FLOSS. Change in learning paradigms is the focus of this next section. It is my intention that by researching how educational paradigms have changed over time and with society, it will yield insights into how the challenges to FLOSS implementations in educational settings might be addressed and overcome by educational technology leaders.

### **Changing Learning Paradigms**

Although at times they may appear to be static, our educational systems and corresponding learning paradigms are complex systems that change and adapt over time. These educational changes often correspond with societal changes. Reigeluth (1994) explained that the reason for these corresponding changes is because educational systems and paradigms are part of the greater societal system. He described the three great waves of societal change (Table 1) as the Agricultural Revolution, the Industrial Revolution and the Information Revolution. With each of these revolutions society has seen paradigm shifts in all of its systems.

**Table 2 - Major Paradigm Shifts in Society (Reigeluth, 1994, p. 5)**

Society	Agrarian	Industrial	Information
<b>Transportation</b>	Horse	Train	Plane & car
<b>Family</b>	Extended Family	Nuclear Family	Single parent/duel income
<b>Business</b>	Family	Bureaucracy	Team
<b>Education</b>	One-room school- house	Current System	?

When the agricultural and industrial revolutions brought about substantial changes in transportation, family and business, education also changed. During the industrial revolution, schools changed from one-room school-houses with multiple grades to larger single-grade, factory-style schools and systems. Unfortunately, the systemic changes education experienced during the industrial revolution have been the

Only time in the history of the United States that education has undergone systemic change—from one-room schoolhouses to the industrial, assembly-line model we have today. The current system is substantially the same as it was when we became an industrial society. (Reigeluth, 1994, p. 4)

This industrial-age model utilized by education has been extensively examined and questioned by educational theorists. As society enters the “Information Age” (Reigeluth, 1994, p. 5) or the “Knowledge Age” (deWaard, 2011, p. 94) changes to our educational systems appear to be inevitable. Reigeluth predicted that this change will be substantial because, “Society has been changing in such dramatic ways that we need a new

educational system that is as different from our current system as the automobile and airplane are from the railroad” (1994, p 5). deWaard agreed and further explained,

This shift also has a profound effect on the leading education model used in the Industrial Age that has served as the balanced pedagogical framework for the past century. While the educational model of the Industrial Age focused on the linear transmission of information and knowledge, educators of this era search for a system dynamic enough to complement the new realities of the Knowledge Age. (2011, p. 94)

Reigeluth posited that paradigm shifts in society cause (or require) paradigm shifts in all societal systems:

This position may explain why educational performance has generally declined in the United States since the early 1960s, while educational costs have dramatically increased. Furthermore, it indicates that the situation will continue to get worse no matter what piecemeal changes we make and no matter how much money we pour into the current system (1994, p 6).

This is because piecemeal changes will not transform education in a manner that keeps pace with society and money, unless directed towards supporting a paradigm shift, will also not cause the conditions that will enable a paradigm shift in education.

Although not included in Reigeluth’s table or explanation on the major paradigm shifts in society, popular learning paradigms have also shifted over time. The following section contains a discussion on these shifts in learning paradigms, specifically that, “In broad linear development terms, Behaviourism was followed by Humanism, Cognitivism, Social Learning Theory, and Constructivism” (Ashworth, Brennan, Egan, Hamilton &

Sáenz, 2004, p. 4). It is important to note that these shifts in development, although not realistically linear, for simplicity's sake will be presented here in a somewhat linear format.

### **Behaviorism.**

Proponents of behaviorism included Edward Thorndike, BF Skinner, Ivan Pavlov and John Watson (Mergel, 1998). This educational theory was prevalent during the Industrial Revolution. It purported that learning happens as a response to stimuli and that new behaviors or a change in a behavior are as a direct result of an individual's response to a stimuli. In terms of behaviorism's place in the larger societal system of the time, behaviorism was most prevalent during the Industrial Revolution. This was in part because a stimulus-response learning model mirrored the popular factory model. For example, "Behaviorism regards human beings as a part of machinery production, and the people trained with behaviorist principles were not acting as a whole organism, but as a part of a big organismic system" (Tuba, Eret, & Kiraz, 2010, p. 295). Behaviorism was also popular because this form of education was an effective method for training large numbers of workers needed to support the ever-growing number of factories and later, to quickly train soldiers for the First and Second World Wars. Tuba, et al. explained,

Since the Industrial Revolution triggered machine based manufacturing, textile industries, steam-power, technology, factories and urbanization... All these events yielded to both reforms and fall [sic] for human and education. In those years, qualified man power was needed urgently to take place in the industries to work with the machines. To train those workers in a massive and shortest way, the countries were to develop and utilize behavioral techniques. After this period,

rapid-growth of behaviorism could be observed, and important progressions were recorded such as the birth of several books and research studies on the field. (p. 294)

### **Cognitivism.**

Cognitivism began its rise to popularity in the 1950's (Ertmer & Newby, 1993; Miller, 2003; and Watrin & Darwich, 2012), during the first part of the Information Revolution, as behaviorism's popularity "began to falter because aspects of learning such as memory, language and other mental abilities could not be considered within its core logic" (Ashworth et al, 2004, p 7). An example of this is that, "children do not imitate all behavior that has been reinforced. Furthermore, they may model new behavior days or weeks after their first initial observation without having been reinforced for the behavior (Mergel, 1998, p. 6).

During this time when behaviorism was being questioned and cognitivism was becoming more popular, computer technologies were also on a rise (Ashworth et al, 2004; Watrin & Darwich, 2012). This, "growth in technology, especially computers and electronics, brought a new focus on mental processes for psychologists" (Ashworth et al, 2004, p. 7) because, "The analogy between mind and computer came to be a central feature of cognitivism..... The computer metaphor was born and would become an alternative to behaviorist explanations" (Watrin & Darwich, 2012, p. 271). One paradigm shift that cognitivism brought about was a shift from teacher-focused instruction to learner-focused. This occurred in part because of the difference between cognitivism's approach to teaching and learning and behaviorism's. Behaviorism's focus was only on the observable changes in behaviors brought on by repetition, whereas cognitivism

focused on the thought process or how information is processed by students. Therefore, under cognitivism, the changes in behavior were thought of as indicators regarding what was happening in a student's mind. Based on this belief, "curriculum design became more flexible with ideas of continuous assessment, group-based learning and applied practice being integrated into the learning experience" (Ashworth et al., 2004, p 7).

### **Constructivism.**

Ertmer and Newby (1993) described the change from behaviorism to cognitivism to constructivism as a continuum. They purported that, "As one moves along the behaviorist-cognitivist-constructivist continuum, the focus of instruction shifts from teaching to learning, from the passive transfer of facts and routines to the active application of ideas to problems" (p. 62). Unlike behaviorism that viewed learning as a stimulus-response process, "in the Constructivist model, learning is viewed as a process of making meaning. The learner interacts with experience and environment in the construction of knowledge" (Ashworth et al., 2004, p. 8). However, it is important to note that, "constructivism is not a totally new approach to learning. Like most other learning theories, constructivism has multiple roots in the philosophical and psychological viewpoints of the century" (Ertmer & Newby, 1993, p. 62). Ashworth agreed with this viewpoint stating, "While the thinking that informs Constructivism spans the twentieth century...it was not until the later part of the century that this theory became mainstreamed through practice" (Ashworth et al., 2004, p. 8). For example in 1897, in "My Pedagogic Creed" John Dewey wrote, "I believe that if nine-tenths of the energy at present directed towards making the child learn certain things, were spent in seeing to it that the child was forming proper images, the work of instruction would be indefinitely

facilitated” (p. 80). Matthews (2003) also agreed with the concept of the recent emergence of constructivism stating, “Constructivism as applied to education is a relatively recent phenomenon primarily derived from the work of Swiss developmental psychologist Jean Piaget (1973) and Russian psychologist Lev Vygotsky (1978)” (p. 53).

Constructivism’s shift away from teaching to learning and from the passive transfer of facts to solving problems appealed to guilt-ridden educators frustrated with Behaviorism and Behaviorist educational practices. Jones and Brader-Araje (2002) explained:

Behaviorism swept from the arena of psychology into education with an air of authority that was startling. Schooling became structured around the premise that if teachers provided the correct stimuli, then students would not only learn, but their learning could be measured through observations of student behaviors. The behaviorist movement led to a long series of strategies for schools such as management by objective, outcome-based education, and teacher performance evaluation systems. Behaviorism in schools placed the responsibility for learning directly on the shoulders of teachers. Teachers were led to believe that if learning was not occurring, then it was their responsibility to restructure the environment, determine the most appropriate reinforcement to promote the desired student behavior, or provide a negative reinforcement to extinguish unwanted behaviors. After years of implementation, behaviorism fell short of producing positive effects within the complex context of the classroom and left teachers feeling shortchanged and cheated by a system that placed the guilt for students' failure to learn in their hands. (p. 1)

Given the above-mentioned shortcomings of some aspects of behaviorism, I think it is understandable that constructivism was not only, “welcomed as a *theory of knowing* that more fully explains the complexity of the teaching-learning process” (Jones & Brader-Araje, 2002, p. 2), but has been hailed as, “one of the greatest influences on the practice of education in the last twenty-five years” (Jones & Brader-Araje, 2002, p. 1). Brown (2005) shared this view stating it is, “important to know that constructivism is presently accepted as the most relevant view of learning and that education policies, education models and education practices focus on constructivism”( p. 2).

### **Social constructivism**

Social constructivism is similar to constructivism in that learning is viewed as a process of making meaning. However, the difference between the two is that in social constructivism, the meaning is made in a social context. Jones and Brader-Araje (2002) believed that:

Vygotsky's work has formed the foundation of social constructivism in educational settings. In particular, Vygotsky's emphasis on the role of others, or the social context, in learning has pushed educators to re-examine the extent to which learning is an individual process. (p.5)

Indeed, Vygotsky (1978) described a child's learning in the context of the child's social environment and social behaviour. He stated:

From the very first days of the child's development, his activities acquire a meaning of their own in a system of social behavior and, being directed towards a definite purpose, are frequently refracted through the prism of the child's environment. The path from object to child and from child to object passes through another person.

This complex human structure is the product of a developmental process deeply rooted in the links between individual and social history. (p. 30)

Social constructivism's influence on education can be seen through educators' "widespread use of cooperative and collaborative teaching strategies.... In each of these, the emphasis is on having students working together while sharing ideas and challenging each other's perspectives (Jones and Brader-Araje, 2002, p. 6).

In addition to being advantageous as a theory of educations, social constructivism has also been utilized as a theory of technological change. Winner (1993) described its use as method for guiding case studies on technological change:

As a way of studying the dynamics of technological change...It offers clear, step-by-step guidance for doing case studies of technological innovation. One can present this method to graduate students... and expect them to come up with empirical studies of how particular technologies are "socially constructed." Indeed, the social constructivists promise to deliver a veritable gold mine of those most highly valued of academic treasures: case studies. (p. 366)

However, despite praising social constructivism's ease of use in technological change case studies, Winner (1993) also described why it falls short as a theory of technological change. He explained that although it is useful for observing why and how technologies arose, it does not address these technologies' consequences to society of. He wrote:

The most obvious lack in social constructionist writing is an almost total disregard for the social consequences of technical choice. This is a social theory and method geared to explaining how technologies arise, how they are shaped through various

kinds of social interaction. ... But the consequences of prevailing are seldom a focus of study. (p. 368)

In addition to his concern regarding social constructivism's lack of ability to address the impact of technologies or technological change on society, Winner (1993) expressed concern that its focus on how technology is created disregards the need to reconstruct our world in order to face a myriad of societal and environmental challenges facing our technology-centered world. He explained:

In the late 20<sup>th</sup> century, a great many people-scholars and ordinary citizens alike-have begun to realize that the key question is not how technology is constructed but how to come to terms with ways in which our technology-centered world might be reconstructed. Faced with a variety of social and environmental ills, there is growing recognition that what is needed is a process of redirecting our technological systems and projects in ways inspired by democratic and ecological principles. How that reconstruction might occur is an open question, one ripe for widespread study, debate, and action. I believe it to be the great challenge for cross-disciplinary thinking during the next several decades.... In sum, the search for a meaningful theory of technology has by no means achieved "closure." It must begin anew. (p. 376)

These shortcomings of social complexity, as described by Winner, namely the need to look at technological changes within the context of society as a whole, are addressed by complexity theory.

### **Complexity.**

In the 1980's research utilizing complexity thinking increased. In fact, the period "1980 through 2000... was a time of explosive growth in complexity research. Indeed, as evidenced by the recipients of Nobel Prizes in physics, medicine, chemistry, and economics, it was the coming of age of complexity" (Davis & Sumara, 2012, p. 31). However, this growth in the use of complexity thinking in the sciences was not shared, at least initially, by education. Gough (2012) explained, "Education research may have lagged behind a number of other fields in recognizing the implications of complexity for conceptualizing the objects of its inquiries" (p. 41). As with cognitivism and constructivism, complexity also "offers an alternative to modeling education on simplifications of industrial systems, such as the so-called 'factory' model of schooling" (Gough, 2012, p. 43). Biesta & Osberg (2010) agreed, stating complexity has "questioned the appropriateness of the machine metaphor that appears to inform expectations about control and perfection in education" (p. 2). Similarly, Morrison (2008) described how complexity is far more than a mere alternative to the factory model of schools, but an opportunity for a complete redefinition of education:

Complexity theory affords the opportunity for a re-awakening of such topics which have lain dormant in climates of increased control of education, heavy prescription and mandated content, reinforced by high-stakes assessment systems and constant surveillance of an individual's performance against predicted targets. Complexity theory redefines 'the basics' of education, away from a controlled and controlling discipline-based education and towards a discovered, inter-disciplinary, emergent curriculum, and a reassertion of freedom as a *sine qua non*

of education. Complexity theory takes us in a direction opposite to the neatly stated, over-determined, tidy, traditional, externally mandated and regulated prescriptions of governments for the aims, content, pedagogy and assessment of learning and education. (p. 24)

Despite Morrison's positive outlook regarding complexity theory it is, "difficult, if not impossible to define or fully understand" (Morrison, 2008, p. 19). Davis and Sumara (2008) agreed with Morrison on the difficulty in defining complexity theory. They stated, "complexity thinking is young and evolving—and as we develop, it refuses tidy descriptions and unambiguous definitions (p. 33). Davis and Sumara (2008) further explained the difficulty in defining complexity:

The transdisciplinary character of complexity thinking makes it difficult to provide any sort of hard-and-fast definition of the complexity movement. Indeed, many complexivists have argued that a definition is impossible. Complexity thinking might be positioned somewhere between a belief in a fixed and fully knowable universe and a fear that meaning and reality are so dynamic that attempts to explicate are little more than self-delusions. In fact, complexity thinking commits to neither of these extremes, but listens to both. Complexity thinking recognizes that many phenomena are inherently stable, but also acknowledges that such stability is in some ways illusory.... (p. 34)

Despite the above-mentioned difficulty in defining complexity, several authors have described complexity theory in terms of its use as a lens for viewing complex systems. For instance, Gough (2012) described a complex system as one which is, "open, recursive, organic, nonlinear and emergent" (p. 41). Morrison (2008) described

complexity theory as, “a theory of change, evolution, adaptation and development for survival. It breaks with simple secessionist cause-and-effect models, linear predictability, and a reductionist approach to understanding phenomena” (p. 19). Theorists have also been forthcoming in their descriptions of the characteristics of complex systems. Davis and Sumara (2008) describe a complex system as one that learns and is “self-organizing, self-maintaining, and tend to be nested within (arising from and giving rise to) other systems” (p. 36). They then describe a complex system’s characteristics as “Diversity, redundancy, neighbor interactions, and decentralized control. Plus negative feedback loops, positive feedback loops, the possibility of dying, memory, stability under perturbations, reproductive instability” (p. 42). Morrison (2008) further described a complex system as one that contains the features of self-organization: adaptability, open systems, learning, feedback, communication and emergence (p. 19) and he described closed systems in equilibrium as systems that will die. Morrison posited that, “systems need disequilibrium in order to survive” (p. 19). Doll (2012) further added to the list of a complex system’s characteristics stating, “It is these two concepts—fractalness and self-organization—that characterize the ‘nature’ of complexity (p. 18) and that a complex system has “the ability to develop states of higher order, differentiation and organization; indeed to create newness from itself via its interactions” (p. 21). Reigeluth’s (2008) list of characteristics included “coevolution, disequilibrium, positive feedback, perturbation, transformation, fractals, strange attractors, self-organization, (and) dynamic complexity” (p. 24). Lastly, Biesta (2010) touched on the characteristic of self-organization and stated, “Complexity is interested in the ways in which open systems achieve their integrity and maintain it over time, a process which is understood in terms of the idea of self-

organisation” (p. 5). She then joined with Osberg (2010) and added four more characteristics, including emergence. They explained:

Complexity’s emphasis on nonlinearity, unpredictability and recursivity is not meant as an argument against or a denial of order. It should instead be understood as a case to see order differently, not as something that can be predicted and controlled from preceding conditions but rather as something that emerges in genuinely generative ways. (p. 2)

Although theorists described the applications of complexity theory as one that helps us understand our world, at the same time they cautioned that this world is constantly changing and that complexity will lend neither perfect results nor perfect understanding. Biesta and Osberg (2010) believed this is because, “reality itself can only be understood as emerging” (p. 2). Gough explained these constantly changing aspects as, “complexity invites us to understand our physical and social worlds as open, recursive, organic, nonlinear and emergent, and to be cautious of complying with models and trends in education that assume linear thinking, control and predictability” (2012, p. 46). Cillers (2010) explained that complexity theory does not provide answers, but a way to understand complex processes and activities in our world. He stated:

There is a growing realisation that there is no coherent “complexity theory” which will unlock the secrets of the world in any clear and final way. Instead, we are beginning to understand more about exactly why complex things are so difficult to understand. We really have no choice but to acknowledge that we have to take complexity seriously, even if it does not guarantee perfect solutions. (p. vii)

## **Complexity as a Theory of Education**

In their recent article, “If things were simple...: complexity in education” Davis and Sumara (2010) posited that, “complexity theory might be properly construed as a theory of education, oriented as it is to better understanding the co-implicated dynamics of many overlapping, interlacing, and nested systems” (p. 856). Previously, and with Luce-Kapler, they explained complexity’s link with education as the “study of learning and learning systems—a notion that encompasses individuals, social groupings, bodies of knowledge, cultures, and species as well as the contexts that are implied when such “agents” are specified” (Davis, Sumara, & Luce-Kapler, 2008). This view of complexity as a theory of education, specifically the elements of connectedness, is shared by researchers such as Morrison (2008), Sen (2012), Biesta & Osberg (2010), Mason (2008) and Ahldeff-Jones (2008) for they all described complexity in terms of its ability to help in the understanding of our dynamic, non-linear and constantly transforming educational systems.

Morrison (2008) posited that, “all complex phenomena and systems have to learn, adapt and change in order to survive” (p. 22). He further explained this applicability to schools as complex systems:

Schools exhibit many features of complex adaptive systems, being dynamical and unpredictable, non-linear organizations operating in unpredictable and changing external environments. Indeed schools both shape and adapt to macro- and microsocietal change, organizing themselves, responding to, and shaping their communities and society (i.e. all parties co-evolve). (p. 22)

Connectedness, as labelled by Morrison (2008) and Sen (2012), is described by Davis and Sumara (2010) as, “overlapping, interlacing, and nested systems” (p. 856).

This connectedness is a, “key feature of complexity theory” (Morrison 2008, p. 20).

Morrison further described the connected elements in educational settings as follows:

Children are linked to families, teachers, peers, societies and groups; teachers are linked to other teachers, support agencies (e.g. psychological and social services), policy-making bodies, funding bodies, the state legislature, and so on. The child (indeed the school) is not an island, but is connected externally and internally in several ways. Disturb one element and the species or system must adapt or possibly die; the message is ruthless. Connectedness requires a *distributed knowledge* system, in which knowledge is not centrally located in a command and control centre. (p. 20)

Sen (2012) saw similar connectedness in educational settings and stated:

There are also interdependent and interconnected variables in education. The curriculum, the school, the teachers, the texts may all be the same, but still the whole is a living and continuously evolving open system. We cannot formulate the education system in an encapsulated and isolated frame. Besides, we cannot isolate the learning experience from the ongoing life of the students. Seen this way, the learning phenomenon and the education system are living open systems. (p. 71)

Biesta and Osberg (2010) viewed the utilization of complexity theory in educational research in terms of its helpfulness in

Describing, characterising and understanding the dynamics of education differently, not in the least because the language of complexity makes it possible to see the non-linear, unpredictable and generative character of educational processes and practices in a positive light, focusing on the emergence of meaning, knowledge, understanding, the world and the self in and through education. (p. 2)

Mason (2008) viewed the utilization of complexity theory in educational research in a similar fashion to Biesta & Osberg. He stated, “complexity theory offers some useful insights into the nature of continuity and change, and is thus of considerable interest in both the philosophical and practical understanding of educational and institutional change (p.5). Ahldeff-Jones (2008) shared a similar view in that he sees the appropriateness of utilizing complexity theory to study transformations in education, however he adds the concept of irreducibility as well. He said:

In the study of education, it should invite us to consider the problems raised by its own irreducibility to existing frames of thought at least as much as the solutions it appears to offer. Complexity should invite us to challenge our ways of interpreting science and-philosophy, as well as our ways of interpreting the world. A specific kind of learning may thus be reinforced in these challenges: the ability of educational researchers and practitioners to build systems of representation that allow them to confront more systematically their own transformation, as they conceptualise the transformation they are studying. (p. 79)

Ahldeff-Jones’ above-mentioned concept of transformation and complexity’s role in the study of transformation is shared by Davis and Sumara (2010). They

purported, “the insights offered by hard complexity research do more than inform education; they transform education” (p. 856).

This final quote from Davis & Sumara (2010) refers to the benefit the use of complexity is to educators. As an educator researching a complex system, I believe this to be an excellent summary of how I view complexity and how I plan to utilize it in my research:

With this shift toward pragmatics and the combined notions of nested, coentangled, and networked learning systems, we feel that complexity/systems thinking has reached a place where it can be of great use to educators – who are, after all, simultaneously concerned with multiple levels of organization (e.g., individual learners, classrooms, schools, school districts, society), co-specifying dynamics (e.g., between teachers and learners, between knowledge and action) and complex associations (e.g., among people, among ideas). Moreover, education is an explicitly pragmatic enterprise. It is charged with the tasks of supporting the wellness and possibility of individuals while supporting the maintenance and evolution of society. Complexity 3.0 enables this work (2012, p. 32).

In this section I provided a substantiated discussion of shifts in learning paradigms, from behaviourism to cognitivism through to constructivism and complexity. I opened with Reigeluth’s views on the links between changes in society and the corresponding changes in education and then discussed these shifts in learning paradigms and the societal influences that preceded them. I then reviewed complexity as a learning paradigm, specifically complexity’s fit as a theory for understanding education and

educational change. As this research focuses on changes and transformations in educational technology, I see complexity theory as an excellent lens for interpreting my findings. The next chapter will discuss, in detail, my research methodology.

### **Chapter 3: Research Design**

I invited one exemplary school district to take part in this research. It is a district in Western Canada that started implementing Free/Libre open Source Software (FLOSS) on thin client machines in 2008, and has now completed their district-wide implementation. The district was only studied over the course of three months, thus yielding a “snapshot” view of the district at one point in time, however many levels of district personnel were interviewed and public documents from outside this timeframe were utilized. Using a qualitative approach, I researched the pragmatic, historical and sociological perspectives of this initiative using a descriptive single case study design. Data was collected using interviews, observations and documents (Patton, 2002) in order to produce a highly detailed descriptive case study research.

#### **Methodology**

This research is best described as a descriptive and intrinsic single case study (Creswell, 2009; Gall, Borg & Gall, 1996; Hancock & Algozzine, 2006; Patton, 2002; Springer, 2010; and Yin, 2009) featuring the enabling conditions established by district leaders and the district-wide change from proprietary software to FLOSS in one exemplary school district in western Canada. I chose qualitative methods with an intrinsic focus and descriptive design because this approach was best suited for yielding a detailed understanding of my questions of “why” and “how” as they pertain to the examination of this district-led initiative. The following sections review and define the components of intrinsic, descriptive case study as they relate to both this research and to qualitative methods.

**Intrinsic motivation.**

An intrinsic (vs. instrumental, collective or comparative) case study focuses on a unique phenomenon. I chose to utilize an intrinsic motivation because I wished to focus on one unique case of district led FLOSS implementation. Springer (2010) stated that “the case that is sampled in an intrinsic case study will tend to be unusual in some respect” (p. 406). This is certainly true in the case I will be studying as only two out of sixty school districts in British Columbia are utilizing FLOSS as their main productivity software and operating system and this is the only district in the province, as far as I was aware, that was undergoing a transition from proprietary software to FLOSS during this time period. Hancock and Algozzine (2006) further defined the use of case study research as a way of delving deeper into an organization. They said:

Researchers engage in intrinsic case study research when they want to know more about a particular individual, group, event, or organization. Using an intrinsic case study, researchers are not necessarily interested in examining or creating general theories or in generalizing their findings to broader populations. (p. 32)

This is certainly true in my research as I was more interested in learning more about this district and the transition to FLOSS than I was in creating theories. However, despite my use of an intrinsic design and the focus on one unique school district, the knowledge resulting from this study may well benefit other schools districts considering or planning district-led FLOSS implementation, or other widespread technological changes.

**Descriptive design.**

A descriptive design matches the perspective of this study in that I have created a narrative that “consist(s) of highly detailed descriptions of people, environments, and institutions, with emphasis on peoples’ interactions and experiences they construct” (Springer, 2010, p. 382). A descriptive design is characterized by Hancock & Algozzine (2006) as an “attempt to present a complete description of a phenomenon within its context.” To this end, and in order to provide these aforementioned highly detailed descriptions, in addition to the semi-structured interview questions (Appendix C and D), I also noted and added to my research descriptions other demographic details such as school clientele, geography, school configuration, school activities occurring at the time as my visits, teacher pedagogy and students’ technology activities.

**Case study research.**

I chose case study research because it can be used to investigate a particular phenomenon on a broad or small scale and because “it provides a unique example of real people in real situations, enabling readers to understand ideas more clearly than simply by presenting them with abstract theories or principles” (Cohen, Manion & Morrison, 2007, p. 253). For my case study, this phenomenon is a select school district that was transitioning to FLOSS. The phenomenon was studied in its natural context and the narrative includes many sources of information, quotes, and anecdotes to bring to life the real people in the real situation being studied. Although a case study of one is not sufficient for the results to be generalizable, I have included highly descriptive narrative which will allow for reader/user generalizability (Gall, Borg & Gall, 1996, p. 578).

Another rationale for choosing case study research is that it is more exploratory than confirmatory. Hancock & Algozzine (2006) explain that although case study researchers may identify themes or categories, they will not attempt to prove a hypothesis. In my case study, although themes and categories were identified during my data analysis, the sole purpose was not to prove existing theories or hypotheses but to explore and describe the unique case I was studying.

Lastly, case study research is an excellent fit with my interpretive framework of complexity theory because “case studies investigate and report the complex dynamic and unfolding interactions of events, human relationships and other factors in a unique instance” (Cohen, Manion & Morrison, 2007, p. 253). This ability to be able to investigate and report on the complex dynamics of my case, an evolving complex system, as well as the human perspectives within this system was vital in providing rich and vivid descriptions of the changing situations relevant to this case study.

### **Interpretive Frameworks**

This inquiry was guided by a complexivist paradigm or world view, based on the contention that societal and educational systems are complex systems within, connected to, supported by and influenced by other complex systems. One characteristic of a complex system is that it must constantly change and adapt in order to survive and thrive. I believe this is true not only of our education system, but of the technological systems nested within it. Technology within our schools needs to change and adapt in order to remain a viable resource for students and teachers. However, when studying the changes to educational technology, the changes must be viewed within the context of the other systems that influence and are influenced by educational technology. For example, when

I studied the changes in the technological systems in my case, I studied them within the context of the school and the society the school was within, in addition to the specific changes themselves.

Under the umbrella notion of complexity thinking (Davis, Sumara & Luce-Kapler, 2000), the worldview pragmatism aligns with my study. I utilized “multiple methods of data collection to inform the study under question” (Creswell & Clark, 2007, p. 23) with an outcome of determining “not abstract philosophy but what works in practice” (Johnson & Christensen, 2008, p. 33). I endeavoured to keep what works in practice, as described by my participants, at the forefront of both my data collection and data analysis because, in pragmatism, “truth is what works at the time” (Creswell, 2009, p.11).

### **Data Generation**

Purposeful sampling was used to select one exemplary case of a Western Canadian school district in which the district led the transition to FLOSS. It was also used to select exemplary interviewees from the teachers and support staff members within this district. Patton (2002) described purposeful sampling as a type of qualitative research that focuses on

Relatively small samples, even single cases...selected *purposefully* to permit inquiry into and understanding of a phenomenon in depth...This leads to selecting *information-rich* cases for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research, thus the term *purposeful* sampling. (p. 46)

Patton's description hold true with how I selected my participants. I purposely selected teachers and staff members who had extensive experience with and knowledge of teaching with technology and could, therefore, discuss the changes they had experienced.

In order to ensure a thorough study, I collected data for a period of three months. This gave me enough time to reach the point of "theoretical saturation" (Gall, Borg and Gall, 1996, p. 567) which occurs when no new data or insights into the case appear to be emerging. In fact, throughout my interviews, there were no discrepancies between my interviewees: they all had different perspectives of the change process, but held similar views and opinions on the successes and challenges of the transformation.

#### **Qualitative data collection.**

I utilized qualitative data collection to study the historical, sociological and ethnographic perspectives on the transition to FLOSS in the school district. To this end, my data collection included "the three kinds of qualitative data: interviews, observations and documents" (Patton, 2002, p. 4). In addition to informal discussions, observing a high school "staff session" with a school staff about to experience the transition to open source software and observing students and their teacher in a school computer lab already utilizing open source software, I personally interviewed the school district's Director of Information Technology (1 hours 20 min) , the districts Technology Coordinator (2 hours 14 minutes) an elementary school vice principal and a school technician (combined time of 1 hour 19 minutes) and an elementary school teacher (1 hour 29 min) in order to obtain detailed answers to and descriptions of my research questions. A list of the interview questions for each of these groups can be found at Appendices B and C and the recruitment that was twice sent out to all district personnel at Appendix A. A third form

of data collection was reviewing documentation on the district-led implementation. These were publically available meeting minutes, technology plans, web sites and articles.

### ***Interviews.***

The one-on-one interviews for this case study were held with participants from a range of positions within the district. The interviewees included a school-based technician, a teacher, a teacher/administrator, the district's Technology Co-ordinator and the district's Director of Information Technology. I selected one-on-one interviews, with similar questions asked to each participant, in order to record the unique observations of different school district personnel working within the same complex system, but in a variety of positions. These interviews focused on participants' perspectives on the district-wide implementation of FLOSS. One-on-one interviews were conducted as guided conversations using semi-structured interview questions (Appendix C and D). I recorded the interviews electronically using two digital voice recorders. I did not take any personal notes during the interviews, although I wrote down my observations both before and after the interviews, as I wanted to give the participants my full attention.

### ***Observations.***

I took extensive field notes based on my observations of the computer lab in the school I visited, student projects I observed and a pre-installation FLOSS meeting I attended. The pre-installation meeting was led by Randy, the district technology co-ordinator and attended by the staff of a high school that was preparing for the majority of their computer systems to change, over the winter break, from primarily proprietary software to FLOSS. The purpose of the session was to give the teachers "just enough, just in time" information so that when they returned after the break, they would be able to use

the new systems for basic tasks such as checking email, accessing the Internet and word processing. Randy reviewed a few of the most common questions teachers had when they were first accessing the new system and answered general questions on accessibility and function. I found it interesting to observe how he tactfully put off very specific questions from teachers about a few pieces of very specialized equipment. He avoided becoming off-track with these questions and instead focused on meeting the needs of the majority and ensuring that their basic technology requirements would be met during their first few days back at school. The availability of the planned support and continuity of services was emphasized. Several times, Randy assured the teachers that although when they returned after the break all the computers and software would be different, all of their passwords would remain the same and there would be plenty of support staff on hand during the transition. Accordingly, Randy himself mentioned that he “sets up office” in each of the schools he is transitioning for several weeks both before and after the school has transitioned to the new hardware and software.

### *School visit.*

During a school visit I collected field notes and I interviewed a teacher-administrator, Karen, and a school-based technician, Pam. Before and in between interviews I was able to observe Karen teaching two different classes in the school computer lab. The first was a grade 4/5 class. The first thing I noticed was how fast the students were at logging on. Once they were logged on, I noticed they all had individualized desktops. The students’ first activity required them to access a local weather website, interpret the results and then take part in a class discussion on the likelihood of the city seeing snow later in the week. The discussion centered on the

meaning and interpretation of 40% and 60% chances of snow. The students' second task on this day was to update their "wire post", which is their class blog housed on the district's secure website. Students were given a teacher-led demonstration, which was displayed on each of their computer screens, and then given time to add their own blog entry. When the students were finished their blog entries, they were permitted to have free time on either math or drawing activities.

The next class to arrive was grade 2/3. Once again, the children were quick to log on and settle in for the lesson. Again, Kathy started off by controlling the image on the students' screens by "pushing" the image on her screen out to the students' screens. She demonstrated how to access the city's weather page, the local university's weather station page and the schools' weather station page. Following this, she led a discussion on 99% humidity and what it means. Students were then asked to play "Hit the Button", an on-line math drills game followed by an exploration of the website, "Cool Math for Kids."

#### ***Written documents.***

The written documents I collected, reviewed and analysed included the district's five-year technology plan, a Master's thesis written by the district's Director of Information Technology that was on the technology the district was implementing, and newspaper articles on the district's FLOSS initiatives. On-line resources I accessed included: awards the district has been nominated for, the district's Director of Information Technology's blog, and district, school and classroom websites.

## Data Analysis

### Software.

Due to the fact that I was conducting research on a school district that was in the process of transitioning the majority of their software to FLOSS, I felt it would be appropriate, if possible, to utilize FLOSS software to analyse my data. I reviewed the following FLOSS computer assisted qualitative data analysis (CAQDA) tools for interpreting and coding the large amount of data I collected:

1. Dedoose is a web-based mixed methods and QDA application created by members of the Semel Institute, Center for Culture and Health, UCLA.
2. AnSWR was created by the Center for Disease Control and Prevention in the United States. It is used for CAQDA of word and image-based information.
3. The Coding Analysis Toolkit (CAT) is hosted by the University Center for Social and Urban Research, at the University of Pittsburgh.
4. InterviewStreamliner is from the University of Rotterdam.
5. Qalyzer is from McGill University in Canada. Their website states,  
Qalyzer is a free and open-source desktop application to support researchers in conducting qualitative inquiries. Qalyzer helps users transcribe interviews, annotate (or code) the transcripts, and generally view and manage information collected and generated as part of a qualitative study. (McGill, 2011, para. 1)

Although they appear user-friendly and have good support forums, I decided not to use Dedoose, AnSWR or CAT because the utilization of these tools required my

data to leave Canada and be stored on their United States servers. Dissertation data storage is not a course of action that would meet with the University of Victoria's ethics approval, nor does it meet my own sense of ethics or professionalism, because it would mean that my data could be accessed by the US government under the US Patriot Act (University of Alberta, 2009). InterviewStreamliner is installed on an individual computer (thus negating the data-leaving-Canada concern), however it does not support Rich Text Documents (such as Word) or audio files, both of which I utilized. Ultimately, I chose to complete my CAQDA with Qvalyzer because it was created by a Canadian University, I will know that my data is safe on my personal computer in Canada, and the software supports Rich Text Documents and audio files, which was a feature I required.

### **Transcriptions and analysis.**

Due to a car accident that hindered my ability to transcribe, I hired a professional legal secretary to transcribe my audio files. Once I received the transcriptions, I listened to the recordings while reading the transcriptions. I did this both to ensure the accuracy of the transcriptions and to re-familiarize myself with the interviews.

I interpreted the transcriptions, observations and documents using inductive and interpretational analysis. Patton (2002) described inductive analysis as “categories or dimensions of analysis [that] emerge from open-ended observations as the inquirer comes to understand patterns that exist in the phenomenon being investigated” (p. 55). Similarly, Springer (2010) described interpretational analysis as “the process of examining case study data closely in order to find constructs, themes, and patterns that can be used to describe and explain the phenomenon being studied” (p. 561). I achieved

this by segmenting the data, developing categories, and coding segments. I conducted this examining, categorizing, coding and drawing of conclusions both as an ongoing process during data collection and several times during the post-data collection review process. The data was word-coded so that it could be cross-checked between documents, observations and interviews as well as sorted into categories. I began coding based on the semi-structured interview question. However, this coding changed two times to fit the actual themes which emerged from the data. By the time I was finished my data analysis, I had coded the data three different times.

## **Participants**

### **District.**

The Western Canadian school district that is the exemplary case I studied has nearly 8,000 students in eight elementary schools, three middle schools, and three secondary schools. The students primarily come from middle income, single-family homes.

At the commencement of my research, there were several districts that were utilizing FLOSS to some degree however there were only two districts that were using (or moving towards using) FLOSS as their primary software. One district, which made the transition to open source software several years earlier, was the focus of my attention until I spoke to the technology director of that district. He informed me that he had not been the technology leader during his district's transition to FLOSS and that the technology director who instigated and led the district-wide change in technology was currently transitioning another school district in Western Canada. Upon learning of this newly transitioning district, I contacted the Director of Information Technology and

asked him for an informal chat. During that 3-hour informal chat over tea, I was introduced to Chris, a man I saw as an excellent leader with a strong vision and the knowledge and experience to effect positive change to the educational technology in his district. I found him to be refreshingly honest and forthcoming as not only was he willing to share the successes his teams experienced, he also shared the challenges, failures, learning experiences and the resulting changes to his approach based on these experiences.

On the recommendation of the director, and with an eye to purposeful sampling of information-rich cases, I contacted his District Technology Co-ordinator, Randy and a teacher/administrator, Karen. Through the teacher/administrator I was able to interview her school technician, Pam. Lastly, despite recruitment emails sent by the district technology team and two all-teachers recruitment emails from the district's teachers' union president, I was only contacted by one teacher from this district who was willing to be interviewed.

**Karen – Elementary school teacher-administrator.**

Karen is a vice principal in a single-track (English) elementary school located in a semi-rural setting with both new and established subdivisions. The school enrolment is approximately 367 students. These students come from a variety of socio-economic backgrounds with the majority of the students coming from middle income families.

Karen obtained her teaching degree from a local university and has a Master's degree in Educational Administration. She has been with the district for almost 20 years and has taught Kindergarten to grade five. Karen brings her own class to the computer lab

for at least one forty five minute block of instruction and practise each week. She also teaches other classes in the lab two mornings a week.

**Pam – Elementary school technician.**

Pam teaches at the same elementary school as Karen. She has also been with the district for 20 years. She told me that all of her computer knowledge and skills have been self-taught. She remembers supporting computers as old as Apple 2Es and carrying tools with her to perform repairs. Pam currently works at the school, supporting technology use, eighteen hours a week. She assists teachers when they bring their students into the lab, which gave her a school-wide perspective on how teachers in her school use technology with their students and how the teachers and students adapted to the new software. In addition to supporting teachers, Pam troubleshoots any difficulties with the schools' technological equipment and acts as a technology liaison between the school and the district.

**Pierre – Elementary school French immersion teacher and librarian.**

Pierre teaches at a large dual-track (English and French) elementary school in a well-established community. The school's 412 students come from middle income homes in single family and rural neighbourhoods in a growing community.

In addition to being a classroom teacher, Pierre works as the school's French Immersion teacher-librarian three afternoons a week. During this time he sees French Immersion students in grades one through five. Pierre has been with this school district for 24 years. He remembered that the initial computer lab had Apple computers. The school then transitioned to a variety of desktop PC's with the latest move to thin client machines running Linux. Pierre often uses technology to support classroom teaching and

learning. He has set up his class web page on the district's Moodle page, uses the computer lab at least two blocks a week and has a data projector in his room. On his class web page he provides educational French links for the students to use and he posts a recording of his weekly dictée so that the students are able to practice their French spelling at home, even if they do not have a French-speaking parent.

Although Pierre has adapted to teaching and working in a Linux environment, he views the addition of the data projector as the most positive aspect of the transition. He utilizes this technology to bring outside activities into his classroom. Pierre explained,

It's immediate and relevant. You know, there are webcams all over the world, and if we are doing Ottawa, we can look at Ottawa's parliament and see what's going on; there's a webcam right in front of the Ottawa parliament. There are webcams with eagles' nests, so it makes it very immediate. That's fun.

**Randy - District technology co-ordinator.**

Randy has been with the district for 21 years. He was a classroom high school teacher and then a self-taught computer lab teacher before moving to his current, managerial role, of "District Technology Co-Ordinator." Based on his background as a computer lab teacher, I found him to be empathetic towards the teachers he is supporting. Although he is in a managerial position, he often thinks about how he would have viewed his district's technological changes if the manager/teacher roles were reversed. Randy said,

Had this come five years earlier when I was in the middle of teaching in a Windows lab, and I was very comfortable with all the software I was using, what would my perspective have been? I can imagine it might have been different.

Randy's empathy and understanding are evident in his statement,

I'm probably a softer touch when it comes to pushing people out of their own world than some of the other folks are. So there are probably a few extra Windows machines in this district because of me, because I'm trying not to make people's heads explode. I think that people deserve a certain amount of time for switching.

**Chris - District director of information technology.**

Chris has a master's degree in Computer Science from Athabasca University. His thesis was on using the same types of technology he is now implementing in his district. Before his current position, Chris spent 16 years as the Manager of Information Technology, in another Western Canadian school district. It was here that he first transitioned a school district to FLOSS. Chris has been the Director of Information Technology in this district for five years. When he applied for this position, he made a presentation on FLOSS and his vision to bring district technology up to date, while keeping it affordable and sustainable. Chris explained:

So when I applied, I ... made a presentation about what I saw as the vision for (this district), which was radically different from anything they'd heard of before, and [I] said this is what we'd done in [in my previous district] and this is what I think we can do [here]. We can even build on what we did [there] and make it so much better...to my surprise they thought it was a great idea. So, not having really had much exposure to open source, or any of these things, the secretary/treasurer and

superintendent and staff said it's worth taking the chance, and talked to my previous district, and they were so happy with it that they said we think we'd like to take the chance and we'll allocate enough funds to make it happen. That was a pretty bold move on their part...but I think it's been fairly successful so far, but it was completely based on that presentation.

### **Validity (Verification)**

Validity in qualitative research may be established through a variety of approaches. Creswell (2009) explained:

Validity does not carry the same connotation in qualitative research as it does in quantitative research, nor is it a companion of reliability or generalizability. Qualitative validity means that the researcher checks for the accuracy of the findings by employing certain procedures. (p. 190)

Despite Springer's (2010) view that, "traditional notions of validity and reliability do not apply to case study data and interpretations" (p. 572), for this research, the "case study tactics" outlined by Yin (2009) were implemented as well as those described by Springer (2010) and Creswell (2009). These tactics include: using multiple sources of evidence (triangulation) and using thick, rich descriptions. Triangulation was used to corroborate information by, "comparing the information obtained from multiple sources" (Springer, 2010, p. 394). These sources are the documents, multiple interviews and observations.

### **Ethical Considerations**

Ethics approval was submitted to the University of Victoria Human Research Ethics Board. This approval was obtained prior to the recruitment and data collection phases of the study. This study was designed to comply with Tri-Council Policy

Statement on the Ethical Conduct for Research Involving Humans. School district approval was also obtained before research commenced. As detailed on my ethics applications, all participants in this study were adults and risk to participating adults was minimal. Pseudonyms have been used for all participants as well as for their schools and school districts. All participants were given an Informed Consent Form (Appendix B) to read and were asked to give their consent before being interviewed. As part of this informed consent process, interviewees were made aware of their ability to withdraw from my research at any time.

### **Summary**

I chose to research district led FLOSS initiatives in one exemplary school district in western Canada using a qualitative, intrinsic and descriptive case study design. I chose this methodology to allow me to produce a highly descriptive narrative with a focus on the educational stakeholders' experiences. The validity of this approach was enhanced through the use of triangulation, and data was interpreted using the theoretical frameworks of complexity theory with the pragmatic approach of acknowledging whether or not the initiatives and their implementation are viewed as working by the educators who use them and the overarching view of this initiative being but one element in the complex make-up of public education.

## Chapter 4 – Research Findings

Upon close examination of my data, I have recognized this case study as a good example of complexity theory at play. Therefore, in this chapter I have utilized the characteristics of complexity theory, as described in literature, to present and interpret my findings. Complexity theory is “a theory of change, evolution and adaptation, often in the interests of survival” (Morrison, 2006, p.1). I have utilized the characteristics because “given the difficulty of offering a one-size-fits-all definition of a complex phenomenon, the most common strategy for deciding if something is or isn’t complex is to look for particular characteristics” (Davis, Sumara & Luce-Kapler, 2008, p. 80).

The complex system described in my study had experienced perturbation and disequilibrium, which led to a transformation of the technological systems in the school district. Reigeluth (2008) described this move from disequilibrium through to transformation. He stated:

Disequilibrium creates a state in which the system is ripe for transformation, which is reorganization on a higher level of complexity. Transformation occurs through a process called “emergence,” by which new processes and structures emerge to replace old ones in a system. (p. 27)

Similarly, Mitleton-Kelly (2003) described this phenomenon as an organization changing and re-organizing. He wrote, “When an organisation moves away from equilibrium (i.e. from established patterns of work and behaviour) new ways of working are created and new forms of organisation may emerge” (p. 13). The change I researched was not small or isolated, but encompassed all technological systems in the entire school district from the smallest elementary school to the largest high school as well as the administrators’

machines and all other computers in the school board office. Therefore, this, “transformation (was) in contrast to piecemeal change, which entails changing one part of a system without changing other parts or the way the parts are organized (the structure of the system)” (Reigeluth 2008, p.27).

With the intent of organizing my findings utilizing characteristics of complexity and in a manner pragmatic to both myself and my readers, the characteristics of the transformation experienced by the exemplary single case I studied are presented in a somewhat chronological order from perturbation through disequilibrium, self-organization, co-evolution, emergence, fractals, core ideas and feedback, possibility of dying, and summing up with the creation of new order and continue exploring space of possibilities.

Construction of these finding was based on the accounts of five educational stakeholders in the district, my own observations at meetings and a myriad of publically available documents and Internet resources. It was my intention that my interviewees would not only be able to recognize themselves in my accounts, but would also find verisimilitude in my work. Lastly, it is my goal that readers from outside the district find my information, accounts and insights helpful, especially if they plan on undertaking a similar journey, of transforming a complex educational system.

### **Perturbances: Why a Change Was Coming.**

*Something has to be done around the province...because the existing model can't be maintained. And people are just hiding from a problem that's coming. (Chris)*

Prior to the district changing all of the computers in the district from Macs or PCs running proprietary software to thin client machines running Free/Libre Open Source

Software, the district's computer systems were ageing, unsustainable and unable to adapt to meet the changing needs of users, or to keep pace with technological changes in society. The district's technology plans acknowledged this perturbation:

Perhaps the greatest challenge we face is the degradation of our computer hardware pool, the aging of our software resources and need to keep current with modern technologies.... The current state of technology is utilizing recycled computers, with our primary operating system and productivity package 7 years old with no plans to upgrade. Consequently technology resources for our children will continue to get more dated as time progresses. (Ferrie, 2010, p. 5)

As a result, user frustration toward this failing system was increasing. All five of my interviewees (a teacher, a school technician, a school teacher/administrator, the district technology co-ordinator and the district director of information technology) commented on their displeasure with their district's previous technological systems. Reigeluth (2008) referred to this unfavourable environment as perturbation and described it as, "any change in a system's environment that causes disequilibrium in a system.... causing the environment to put pressure (perturbation) on the educational system to undergo fundamental change, or transformation (p. 27). Similarly, Mitleton-Kelly (2003) described this situation as a system, "pushed far-from-equilibrium by an *external constraint or perturbation*" (p. 10).

As will be explored later in this chapter, both Chris and Randy mentioned that some of the reasons for this perturbation, or failing technological environment, stemmed from the practice of purchasing off-lease computer systems, the decentralization of technology purchasing, and the technology itself not being upgradeable to meet the present or future

needs of the teachers or students in the district. These problems led to pressure on the system to undergo a transformation.

**Unsustainable and unmanageable.**

*It is an unmanageable system. All you can do at best is maintaining a crippled system. Systems are down all over the place” (Chris).*

The practice of purchasing three and four year old off-lease computers, although initially less expensive than purchasing new computers, contributed to the unsustainable condition of the district’s technological systems. These older computers and the resulting human power required to try and maintain these deteriorating systems, led to an ICT environment that was unsustainable and unmanageable. Chris explained his personal and negative view on the popular practice of purchasing off-lease computers for use in schools:

Let’s find the best possible off-lease computer we can get and stick it on teachers’ desks and just try and manage it, which is the way most districts run right now, to be perfectly frank, that’s the best that they can manage .... I’m thinking why would you want to put in old computers that somebody’s cast off already for the basis of your technology? I mean, I know they’re cheap, but they’re cheap because they’re old.... I just find this whole idea of buying used computers and putting them into schools just so archaic and a hopeless system.

Maintaining the district’s computers was becoming an insurmountable problem, contributing to the perturbation. The computers were often breaking down and the district technicians did not have the humanpower to maintain the outdated hardware and software. Randy described the situation as dysfunctional and impossible, not because of

personnel, but due to the ageing technology the district was, unsuccessfully, trying to manage:

What I think was happening in the district before was we were running some pretty dysfunctional systems. We had our old hardware, people had worked very hard to make all that old hardware the same, but it was still old. They were chasing all sorts of hardware related issues. They were chasing all sorts of problems. They had rooms full of old stuff that they used to cobble together machines...there was so much time spent to make the tool work, and very little time spent learning how to use the tool better. I think the guys in IT basically worked their butts off and were seen as pariahs because they never got caught up. It was just impossible.

Chris agreed with Randy's assessment of the technicians' lack of opportunity to get caught up, and referred to the system as crippled and unmanageable. Chris stated, "That's crazy. You can't manage that. That's the problem (our district) was in. It is an unmanageable system. All you can do at best is maintain a crippled system. Systems are down all over the place."

Alongside the problem of the computers not being sustainable was the issue of ageing software and the inability to upgrade software due to the age of the hardware. The district was not able to keep up with software upgrades because the computers were too old to run the newer software. Randy described the age of the computers in just one of the district's high schools and predicted that merely five of the school's almost three hundred computers could be upgraded under the outdated system:

Right now, in this building, they have 294 Windows machines, and of those machines three or four, maybe five could run Windows 7, and the rest of them are

between three and eight years old...they're doing the best that they can do with what they've got.

**Decentralization.**

*[ICT and ICT purchasing] was completely de-centralized...it was unaffordable...it wasn't achieving, it was breaking down, and things were in a pretty bad state overall. (Chris)*

Prior to the district-wide change in technology from ageing PC computers to thin clients running FLOSS, the district was similar to many area school districts in that computer hardware and software acquisition was de-centralized, “which meant that schools were allocated funds, they had to find the monies to fund their own technology initiatives” (Chris). Although distributed control (Morrison, 2008, p. 22) or order without top-down domination is one principle of a complex system, in regards to the planning and purchasing of technology for a school district, decentralization was seen as dysfunctional because the practice was unaffordable and unsustainable. Randy explained that although allowing individual school's autonomy is appropriate in some situations, the decentralization of technology decision-making and purchasing is not efficient because the on-sale computers that schools were purchasing were not up to standard. Randy stated:

Schools deserve to have some autonomy on lots of things, but it doesn't make any sense to have autonomy and end up having people buying a bunch of computers from Future Shop for \$300 because they were on sale and then just have them die because they're just not up to standard.

Chris also commented on the lack of affordability of a de-centralized system and the difficulties in maintaining and managing it:

Also about de-centralized management, that had become a huge problem. Schools not being able to manage their own systems adequately any longer. Being able to control costs, a lot of those things. ...They'd gotten to the stage where it was completely de-centralized and it was unaffordable for them. It wasn't achieving, it was breaking down, and things were in a pretty bad state overall.

As illustrated by both Chris and Randy's comments, the decentralization of the decision making and purchasing of educational computer systems led to the increase of the perturbances in the district. Based on both their comments and my own experiences, I see the provision of operational technology with a decentralization of how to utilize the technology as much more important elements in supporting complexity than the decentralization of purchasing basic technological systems could bring.

**Unable to be upgraded.**

On 8 April 2014, Microsoft will no longer support Windows XP (Microsoft, 2013). This means that Microsoft will no longer be providing users with security or other upgrades. For schools, the end to upgrades will put them at risk for security breaches and viruses. Therefore, the upcoming removal of support will require many school districts to upgrade the operating system on many or all of their computers. Chris explained that this will become a problem because most of the school computers currently running XP can't be upgraded to run Windows 7 or 8 because they are too old, therefore they will need to be replaced by 2014:

As of 2014 districts will have to move off of Windows XP, at which time it simply won't be usable anymore. So that means a move to Windows 7 or Windows 8, whatever's available. Most of the computers ... will not accept Windows 7 or Windows 8, which means you're looking at a wholesale refresh of thousands of computers by 2014. That's the situation that ...all kinds of districts are faced with; what do you do when Windows XP is no longer supported, and your computers won't run the latest, greatest version of the Windows operating system?

Adding to the perturbation, Chris added that the cost of upgrading all of the computers in a single school district (to Windows 7 or 8) would cost six million dollars, an amount of money that most school districts don't have:

So you've got a nine or ten year-old operating system ... what is going to happen ... how is it going to be supported when the three, four or five thousand computers, which can't run Windows 7, fail? They'll need to spend six million dollars in [our neighbouring district], and it doesn't have six million dollars. It would be exactly the same with ... any of the other districts.

**Unreliable.**

*If you're going to be teaching technology, it better be working. (Karen)*

From the perspective of the teachers, technician and administrators I interviewed, the district's previous computers were unreliable. Teachers did not want to use the unreliable systems with their students. For example, Both Chris and Randy commented on not having enough computers for each child due to the technology not working when it was needed and Pierre and Karen described their firsthand experiences using the unreliable technology with students. Randy spoke from the perspective of a former high

school teacher on the frustration of not having a full lab of working computers and the resulting impact this had on his students:

I mean my record as a lab person was I came in after lunch and 17 of the 29 computers in there didn't work. And I spent 80 minutes getting 15 of them working again. And two of them I never got to during that time. So, kids are sitting and not getting anything done.

Chris also spoke about the inappropriateness of not having one working computer for each child in a school computer lab:

A teacher takes a group into a lab of 30, and 27 of the computers are working, maybe not even that. So you've got three orphaned kids who've got to sit with other kids. That's not the way to do technology.

Both Pierre and Karen described the problem and their frustration with unreliable computers. Pierre said, "With the PC's, it was frustrating when they would break down" and Karen mentioned that, due to the unreliable nature of the machines, some teachers would not bring their classes to the lab. She also articulated her negative opinion on running a computer lab using outdated systems:

It was crazy in the PC lab. In fact, a lot of people wouldn't go in there because it was too much work...If you're going to be teaching technology it better be working.... we were behind. You can't run a computer lab, getting kids who are supposed to be doing technology-based learning, on stuff that's outdated.

In addition to not having reliable computer systems for students, teachers also did not have access to computers that were fast enough to allow them to check their email during their breaks. This led to unreliable communication within the district. Randy described

this situation stating, “Lots of high school teachers did not check their email during the day because there was no time, because the machine took so long to load that a five minute break wasn’t enough.”

### **Disequilibrium: The System Was Forced To Explore Its Space of Possibilities**

... *For the most part people just want the machine to work (Randy).*

In the district I studied, before this social system could transform or emerge, they needed to explore their options and decide on a course of action that would meet the needs of the educational stakeholders in their district. This is referred to as exploring their “space of possibilities” (Mitleton-Kelly, 2003).

In his article entitled *Ten Principles of Complexity & Enabling Infrastructures*, Mitleton-Kelly (2003) used the term “constraint” in the same manner as Reigeluth (2008) used the term “perturbance.” Mitleton-Kelly then described how, when a social entity is faced with disequilibrium or constraint (such as failing technology), it finds new ways of operating by first exploring its options. He has termed this exploring their “space of possibilities” and explained:

When a social entity (individual, group, organisation, industry, economy, country, etc.) is faced with a constraint, it finds new ways of operating, because away-from-equilibrium (established norms) systems are forced to experiment and explore their *space of possibilities*, and this exploration helps them discover and create new patterns of relationships and different structures. (2003, p. 13)

Part of the district’s exploration of its space of possibility involved looking at situations that they did not wish to emulate and equipment they felt did not meet their needs as well as assessing their needs as a district and reviewing situations and equipment that might

meet their needs. As reviewed in the following section, the district's needs were for reliable, sustainable technology and web access that was not based on proprietary software or the utilization of used equipment. They were looking for a more centralized approach to technology purchasing and management and lastly, the concept of bring-your-own-device, providing mobile devices and access to this new system was considered as part of the district's decision-making processes. Accordingly, the district's technology plan described an affordable, reliable and secure system that was available to students 24 hours a day, 7 days a week:

The "network" or communication infrastructure is the cornerstone for enabling centralized shared resources ...and lowering technology total costs of ownership (TCO). A reliable, pervasive, high speed Wide Area Network will bring our schools and administrative sites together and strengthen our ability to enhance educational opportunities to our students.... Information must be available securely and reliably not only during traditional school times but more often as we move to ... a 24/7 model. (Ferrie, 2010, p. 4)

**Off-lease computers.**

Based on the previous poor experiences the district had with off-lease computers, Chris argued against utilizing used computers for the district's future technological endeavours. He explained:

So really having a different approach to technology rather than just putting boxes, used boxes, on teachers' desks. That's the model that's been done, for the most part. I wouldn't want to be at all judgemental about [another district's] technology plan. I'm thinking why would you want to put in old computers that somebody has

cast off already for the basis of your technology? I mean, I know they're cheap, but they're cheap because they're old.

**Reliable technology.**

Randy saw the main needs of the district's schools as having relatively fast Internet, access to productivity software (word processing, spreadsheet and presentation software) and reliable technology. He stated:

For the most part what the schools need is reasonably fast access to a web browser and they need productivity software and that solves the needs of so many of the people in the building ... for the most part people just want the machine to work.

Chris agreed with Randy's view on reliable technology in the schools. He saw it as something that should be utility grade, or the same as lights and power. Technology should be something that is expected to be working at all times. He explained, "It needs to be utility grade, which is when you bring your class in you don't want to worry about [the computers].... You want to turn them on and it just works; it does its thing" (Chris).

**Centralized purchasing and technology management.**

Randy commented on the practice of individual teachers using school money to purchase technology that may or may not have an educational purpose and that the district may not be able to support. As a former technology teacher and now working in a district role, he does not agree with the practice of individual teachers purchasing technology. He believes that technology purchasing needs to be centralized so that all purchased technology equipment has an education rationale, is reliable and the district is able to support the technology. He argued:

I just don't think it makes sense for people (if they've got a little money in their account for their department and that happens in high school) to venture out into a technology store and buy something because they think they'll like it. I think there needs to be some educational rationale and it needs to be vetted enough so that we say we're not going to buy that because we just can't support it, it's not going to last long enough, or it's not going to do...just because you think the iPad is really cool doesn't mean it's a good idea.

This centralized approach to decision-making Randy described is more akin to the provision of utilities than teaching supplies. Just as the district does not have teachers making purchasing decisions on lights, power, water or sewage, they are also not making the decision on the provision of reliable technology. Chris explained centralized management is "having someone who would be directing technology and integrating it with education for the future" and that he sees this as a better solution than decentralized ICT purchasing. He explained his rationale and then continued on to explain that this utility computing was just the first step, with using ICT wisely being a more important next step:

"I thought that we had a better solution... get[ting] into something which we would prefer to call 'utility computing' where, just like the power and the telephones, it just works. And then we can get on to the really important stuff, which is how to use it wisely. How to help teachers with it, provide more professional development, listen to teachers and just do more with it, as opposed to just try to maintain a failing system.

**Open source software.**

While considering its options, or exploring its space of possibilities, the district considered and selected the route of changing as much of their proprietary software as possible to free/libre open source software (FLOSS) running on thin client machines. Chris explained that this decision was made based on the interview presentation made by himself the (now) Director of Information Technology:

They posted the position for a director....when I applied, I actually made a presentation...about what I saw as the vision for [this district] which was radically different from anything they'd heard of before, and said this is what we'd done in [my previous district] and this is what I think we can do in [your district]. We can even build on what we did [before] and make it so much better...they thought it was a great idea. So, not having really had much exposure to open source, or any of these things, the secretary/treasurer and superintendent and staff said it's worth taking the chance, and talked to my previous district, and they were so happy with it that they said we think we'd like to take the chance and we'll allocate enough funds to make it happen.

There were many reasons for this decision, but the main ones were reliability, upgradability, cost, and the utilization of non-commercial, community-made software. Before this transition to thin clients and open source software, this district, as with their surrounding school districts, utilized proprietary software and ran it on either PC or Macintosh systems which, as described previously, can be more problematic and expensive ICT choices.

When Chris was describing the district's new technology plan and explaining their goal of utility computing and ensuring that everything worked so that they could move on to more important things such as how to use technology wisely, I asked him if there were any other reasons, such as ethics, that contributed to the decision to use open source software. I asked this question based on the ethical concerns I had as a teacher and on the influence, as described in chapter two, that the utilization of commercial software has on children and families. He replied that the desire to utilize non-branded software did come into play as did the desire to use a community-built resource. Chris explained:

Well, it was part of it, for sure. They really liked the idea of open source not being branded software, where you're bringing in Pepsi or Coke or something like that, you're actually bringing in something that's community based, that the community helped build.

During our interview, Randy explained his personal views on proprietary software and how he believes that although large corporations have produced excellent software, the expense, schools' dependence on it and the fact that schools must replace their computers in order to run the new software is not in education's best interest. Randy also explained that he believes that once a tool or resource becomes widespread it should not necessarily be allowed to continue to be proprietary:

I think that the corporate world has brought us some amazing software, and it's brought us some amazing hardware. At the same time I think they've led us down a proprietary path that I don't know is necessarily in all of our best interest. When technology was a tool that you spent a pile of money (on) to get a tool to do a job, then it made sense. But when it became like the air we breathe and the water we

drink---it is literally everywhere...Ubiquitous? Pervasive? I think the Internet is one of those things.... It shouldn't be allowed to be proprietary. I don't think that the web should be full of proprietary things, like when we try to browse something on our system and for some reason it doesn't work because it's got Shockwave or something like that, that's crazy.

Randy also discussed how he liked the idea that open source software was developed by a community of people working together. This positive view on a product made by a community working together aligns with how members of society work together. As discussed in my literature review, Randy's view on open source software is also shared by communities of researchers studying FLOSS, such as BECT (2005) and Bacon & Dillon (2006). Randy also described his concerns regarding the preponderance of Windows operating systems, how testing is done, the high demands the software places on computer systems (Randy refers to this using the term 'heavy') and the resulting requirement for frequent hardware upgrades:

This is about water, air, the Internet. That's some of what I like about (open source). I also like the idea that this is a community of people... I don't think it's fair that ninety-something percent of the operating systems in the world are Windows. We're kind of owned at that point. And I don't like that they started beta testing the public, and I don't like the fact that every time they push out a new piece of software you need to buy a new piece of hardware. I can't help but think that there's a little bit of a conspiracy around that. I think that their operating systems and their programs are incredibly heavy, and they just get heavier and heavier.

As with any decision a school board makes, the financial impact of that decision needs to be considered. In this instance, the district had to weigh the initial upfront costs of the transition to new thin client machines with the predicted power savings, maintenance savings and cost free upgrades. The district's technology plan acknowledged their financial concerns and their position that this course of action would yield a cost-effective solution:

The reality of declining ... budgets also indicate that we must make the best use of the dollars we have available....Rather than do little with fewer resources we have taken the initiative to resolve the challenge of fewer dollars and greater requirements for technology by utilizing some extremely innovative technologies in our administrative and schools. (Ferrie, 2010, p.4)

Accordingly, Pam succinctly described her view on why the district chose this route. She said, "Because (they) see that as the way of the future and it's in the end going to save money. We all don't have enough money." Pierre, shared Pam's opinion on the cost savings, but added that it would also give them a more current technological system.

Pierre explained:

I think for them it was the cost. They felt it would be cheaper even though it was a big investment in time and labour to put it all together, but for them it was to be within this century, type of attitude.

As Chris was directly involved with the decision making process, he, unlike Pam and Pierre, did not need to speculate on the rationale for the decisions. Chris outlined the savings in power stating "Our energy manager estimated a 70% savings... We were being conservative." Chris also explained that although the life expectancy for the servers

running all of the thin client systems is only four years, replacing servers every four years is less expensive than replacing all of the PC computers every five to eight years:

The server's life expectancy of about four years, but a ten thousand dollar server and a secondary is a lot cheaper than Windows based PC's that have a life expectancy, theoretically of five years, but schools are running them to eight years, when they become absolutely unusable.

**Bring your own device.**

The concept of "Bring your own device" was and is still an option being considered by the district. It is a situation in which the school provides wireless Internet access and students are encouraged to bring their own computer, tablet, phone or other wireless device from home, to use at school. Chris commented on how he believes that although this is what the provincial government would prefer, that it is not a feasible option for middle or elementary schools:

The government, I think, is all in favour of Wi-Fi and bring your own device.

They'd love students and parents to take the ownership of this, so we'll put Wi-Fi everywhere, you bring your own device and other than that, that's all we're going to do for you. I think that's the model that they're moving to in the future. The only problem is that won't work in middle and elementary schools because there are parents that will just scream blue murder if you put Wi-Fi pervasively through their schools, and it's only going to get worse and worse. It might work at secondary, but it won't at elementary and middle schools.

Chris also discussed the challenges of utilizing both bring-your-own-device and school-provided mobile devices. Although he believes it could work in the district, he

maintained that access to the technology would need to be equal and the issues of their prohibitive cost, fragility, unreliability and frequent upgrades would need to be addressed:

The bring your own device, I can see it working, but it has to be equitable, where all the kids have equal access to things and I'm just not sure how to manage that....

I think the challenge is the money. A tablet is four or five hundred dollars for a good tablet or a good Android device, and maintaining them from damage or dropping. We've ... tried Kindle experiments...a lot of them failed. They go missing. And they're a good machine, it's a good solid machine, as is the iPad, but there's a new iPad that comes out every few months and the technology becomes archaic so rapidly, I just don't think school districts have the funds to put a tablet or a netbook in the hands of every student, I don't know how we could possibly do it.

Chris gave an example of one district in British Columbia, spending three million dollars to implement a one laptop per child program. Due to the limited lifespan of laptop computers and the occurrences of them being stolen or dropped, the program was unsustainable. Chris explained:

Districts have tried. [One district] put three million dollars in a one-to-one laptop program for grades five, six, and seven, and they scrapped it because of the huge amount of laptops that went missing, were dropped. They simply just couldn't maintain them. Laptops have a shorter lifespan than desktops, so three year life. They're having to refresh an entire system that cost them three million dollars every three years. It just can't be maintained... We can't sustain it, unless you come up with a \$100 device that does everything. Which they are working on.

## **Self-Organization**

... *We have such good support. I cannot say enough about it. (Pam)*

The transformation of an organization occurs through the processes of self-organization and emergence (Mitleton-Kelly, 2003; Reigeluth, 2008). Mitleton-Kelly (2003) describes self-organization as, “the spontaneous coming together of a group to perform a task (or for some other purpose); the group decides what to do, how and when to do it; and no one outside the group directs those activities” (p. 20). In the district I studied, no one outside of the district decided or decreed that the technology be changed. Additionally, all of the decisions regarding what to do about their technological challenges, how to make the changes and when to make them were made by from within the district, by the superintendent and his staff members.

I utilized the key characteristics of: 1) enabling infrastructures; 2) trust; and 3) communication to interpret and organize this self-organization section. These characteristics are based on those listed by Reigeluth’s (2008), Mitleton-Kelly (2003) and Morrison (2008) and include enabling infrastructures, trust and communication and connectedness.

### **Enabling infrastructures.**

Enabling infrastructures are those structures which enable and facilitate change in an organization. Mitleton-Kelly (2003) asserted that:

If organisation re-design were to concentrate on the provision of *enabling infrastructures* (the socio-cultural and technical conditions that facilitate the emergence of new ways of organising), allowing the new patterns of relationships and ways of working to emerge, new forms of organisation may arise that would be

unique and perhaps not susceptible to copying. These new organisational forms may be more robust and sustainable. (p. 14)

Some of the enabling infrastructures mentioned by my interviewees include management behaviours, training, technical support provided in support of the transformation process, and trust between educational stakeholders.

### ***Management.***

In a complex organization, the term “management” takes on a different meaning than in the past. In a complex organization, managers stimulate emergence and self-organization for it is these characteristics of a complex system that are internally generated and considered the “antithesis of external control” (Morrison, 2008, p. 21). Similarly, Tasaka (1999) referred to an enabling managerial approach or characteristic as “knowing emergence” and described it as:

An approach to the world [which] teaches us the importance of not trying to plan or manage things artificially, but emphasizes instead ways to stimulate the process of self-organization. For that reason, managers must study deeply the following paradigm shift that knowing emergence teaches us: *Don't plan or manage, stimulate self-organization.* (p. 118)

One aspect of the district's enabling infrastructure was financial. The district set aside, “approximately two million dollars ...for this initiative for a three year period” (Chris). However, the district's support was more than purely financial. Chris described how the management of the district worked together as a team in support of the transformation and how he believes this enabling infrastructure is important, if not vital, for a successful transformation,

The senior executive, that's the superintendent, secretary, treasurer, assistant superintendent, have to be absolutely a cohesive unit....they have to work as a team. And this district works as a team, without a doubt....I'd say having executive sponsorship across the entire board is so important. They work as a team, unquestionably. I haven't always seen that, business and education sometimes barely talk to one another, and this would be a challenge in that environment.

Chris further described the how the attitude of senior management was another component of the enabling infrastructure. Although my data does not describe how this relationship came about or was maintained, it was clear to me that a positive and enabling relationship did exist. Chris described the district superintendent's positive attitude towards the new technology and his rationale for this support, "Our superintendent has become an open source zealot... he and the secretary/treasurer and the board are 100% behind it, because they can see the moral, ethics and efficacy of open source. It just works." Although, from my outside observations, Chris was primarily working on his own to plan the implementation of the changes to the district's technology, I see this as an effective change process. I think it was successful because he, as the manager or leader of the transformation, stimulated self-organization, provided enabling infrastructures, supported shared values and encouraged the exploration of the space of possibilities. In essence, he exhibited the managerial behaviors and provided the conditions to encourage self-organization that are described by Mitleton-Kelly (2003), Morrison (2008), Tasaka (1999), and Reigeluth (2008).

### ***Training and professional development.***

Although the words “training” and “professional development” are sometimes used interchangeably, for the purpose of clarity I will use the word “training” to refer to teaching users the basics of how to navigate and use the new software and hardware and the term “professional development” to refer to learning how to use the technology to enhance teaching practices. These two terms were also used in this manner in the district’s technology plan. Training and professional development were specifically outlined in the district’s technology plan. The plan specified how much of the budget should be allocated for training and professional development of teachers and other staff members and cautioned that technology initiatives will not succeed unless effective and on-going support was provided:

Technology initiatives will fail unless they are supported with effective, on-going maintenance, technical support, and staff development. The general rule of thumb is that schools should allocate 30 per cent of their technology budgets to training and professional development. (Ferrie, 2010, p. 7)

The plan further clarified that simply giving teachers reliable technology is not enough and that both reliable technology and professional development on the technology was required and therefore included in the technology plan. It admonished that,

Simply putting a connection and a computer on every teacher’s desk will not intrinsically produce effective communications. Professional staff will require professional development and administrative and support staff will require training to make the most efficient and successful use of the resources that are becoming

available to them. Therefore a critical component of our strategy has to be an effective training and professional development structure. (Ferrie, 2010, p. 4)

There did not seem to be any district-wide technology-related professional development opportunities before this initiative. Previously, the district did not have a director of technology, it was a secondary responsibility for teachers. Chris explained that “they would hire a district principal, or district teacher, or [district technology planning was] done off the side of the secretary/treasurer’s desk, or something like that, and technology was done in a different fashion altogether.” Additionally, as there was no uniformity in either operating systems or software amongst the district’s schools, any attempt at professional development would be difficult as not all software was available at every school.

The initial training on the new hardware and software, outlined in the technology plan and provided by the district’s technicians, was viewed favourably by both Karen and Pam. Before this district initiative I believe training would have been done on a school-by-school basis and provided by individual school-based technicians because technology purchasing was decentralized and therefore a school-based initiative. Karen described the overall transition and training as a smooth process and stated,

They gave us a date and [then] the whole thing only took a week for them to come in, get the machines set up, get it all running. There were three tech people onsite for that whole week, working with people and they were there to solve any problems that came up. It was really smooth. ... And we had the teachers come in and work with those tech people to go through the basics. And that was total side-by-side support. I think that’s how it looked in most schools.

The school-based technician, Pam, also viewed the transition in a positive light. She described how the transition took less time than anticipated and how the students quickly adapted to the new software and hardware:

It was good...it didn't end up taking a whole week ... they just came in and took all the stuff out and put all the new stuff in, and Randy was here to be with the classes as they came in here and walk them through it. And you know, the kids picked up on it really quickly.

Pam also described how the significant training resources provided by the district made the transition happen smoothly. She explained, "... we had teachers come in with their classes, and I think we had some just teacher things. [The district] did put a fair bit of resources into the training, which was great. It makes [the transition to new hardware and software] go a lot smoother."

***Support.***

When describing the behaviors of the district's technology co-ordinator, Randy, Chris emphasized how Randy provided enabling infrastructures by staying at, and working out of, the transitioning school until his support was no longer needed. He stated:

[The techs] basically parked there until schools were ready to sign them off. So Randy is ... slowly weaning himself off of [one high school] and he's starting to head to [another high school] to get ready for spring break. He spent about three plus weeks helping staff and students and technical support people there, and he's pretty much done.

Karen, Pierre and Pam all found that the district-provided support that Chris described also met their needs during the transition. Each one of them described only positive experiences. Karen mentioned that support was key and stated, “That’s been one of the key things; the immediate tech support has been phenomenal. Pierre agreed with Karen’s sentiments stating, “The training...you talk about ... Randy... he was very accessible; whenever I needed him he came. The support was there as long as you wanted to call on it. Similarly, Pam added, “... we have such good support. I cannot say enough about it.

Randy described the aforementioned support he provided during the transition and how he viewed his role as one of utilizing any opportunity he had to help people use technology in a more efficient manner:

I talk to them about productivity software, not anything that they couldn’t do before, but how they can do those things better. I talk about file management and bookmark management and Moodle and all sorts ...I used every single one of these opportunities as a great way to do what I think my job is which is to work with teachers.... It’s given me a great chance to do my job. So, I’ve seen these as exciting, because I’ve had a captive audience, and they’ve asked me about all kinds of things and I could look over their shoulder at their email and said, “You know you could do this differently,” about tagging or creating folders, or I’m looking at their Moodle page and did you know we could do this, and all sorts of things.

Basically dealing with all of them individually and trying to assess where they are and moving them a step forward.

Lastly, Randy described the support and training his team of technicians provided while they were transitioning a school from PC computers running Windows to thin client

machines running Linux and LibreOffice. He explained why they utilized the “just in time” training model, the flexibility of it and why it was successful in their situation:

The just-in-time thing is what we’ve always used, and it works well because we put so many people here. Having three, four, five, six people here in the building, including the school tech we can just run as fast as we can and get to everybody. So, they miss us when we’re gone, because nobody’s ever had that kind of service. No matter how good their tech is... we try as much as we can to solve problems as quickly and as efficiently as possible that week. And essentially I do just-in-time for a month, and I’ll run as many sessions as they’ll let me ...I’ll runs whatever sessions people want.

### **Trust.**

A sufficient level of trust between different educational stakeholders groups is a component of self-organization needed for a complex system to undergo transformation (Reigeluth, 2008). Fortunately, despite province-wide teacher job action and the resulting province-wide climate of mistrust that I noticed between teachers and their employers, Chris described the relationship between teachers and the board as a positive one. He described the relationship between the teachers’ union as positive and the reaction of the teachers’ union to the changes as, “somewhat benign.” Chris clarified:

We didn’t get any resistance from the teachers union. It’s been a good relationship, though, I think. [Our district] has a pretty good relationship with the executive. There’s a lot of mutual respect and there seems to be a good relationship between the board as well as teachers’ union ... So there hasn’t been any pushback...the teachers I’ve talked to have been pleasantly surprised.... I’m not getting teachers

complaining bitterly about it. But actually the opposite, that they're surprised that [the new hardware and software] works as well as it does.

In my experience, when a district initiates a district-led initiative without consulting the teachers' union the initiative is seen as top-down or something being "done to" teachers by the district and is often met with resistance and pushback. Therefore, I see this situation as different from the ones I have experienced as this top-down initiative was not met with resistance.

The relationship Chris described above was neither confirmed nor denied by a large sampling of teachers. Despite my efforts to get teachers to talk to me – Randy and the teachers' union president put out emails on my behalf – I only interviewed one teacher and one teacher-administrator, therefore I have more interview data from district leadership than I do from teachers in the district. However, as a teacher in a different district I fully understand how busy teachers' days are and believe that had the new technology been an inconvenience or not educationally sound, I would have had many more teachers wishing to discuss it. Therefore, I take the fact that there wasn't a teacher uprising, or dozens of teachers wanting to discuss or complain about the changes to their technology to indicate that the transition was not a hardship to teachers. As a researcher I would have liked to have heard more voices from the teaching population, so as to either confirm that the relationship and change in technology were, as described by Chris, positive or to point out the downside or challenges to the relationships or to the changes in technology.

In addition to trust between the teachers and the school district, Randy described a situation in which he, as a district leader, needed to trust that a principal was able to make

decisions on the technological training requirements of his staff. Randy explained the message of trust he tried to portray to school administrators:

The message that I gave to every administrator that we saw was: I want to work with your staff. These are the things I want to do with them. I want to work with your staff in the way that you think would be best. You help me schedule it, you decide, it's your school, you know these people better than I do. (Randy)

Although, in my experience, free technological assistance is generally welcomed in schools, Randy also had to trust principals and schools to decide how many computers they required (the district transition replaced computers one-for-one) and if schools needed to maintain any existing proprietary systems in order to meet teacher and student educational needs. Randy also described how he was asked, at one of his schools, to run sessions on the new technology *prior* to its installation. This was a different approach to what he had done previously, so he needed to trust that the school principal was making a good choice for his particular staff. He noted that, although it was successful in this instance, it may not have been with other school staffs:

When I got to ... our eleventh school the principal said, 'I don't want you to come and teach them this stuff after. These guys are plenty capable. Can you show it to them before [the new hardware and software is installed]?' I said, 'sure' ... (Randy)

The reason for this request was that the principal felt his staff were technologically savvy enough to be able to understand and remember the basics of the new technology based on information sessions held prior to the installation, whereas most of the schools waited until the new technology was installed and operational before holding the information and supporting hands-on learning sessions.

### **Communication and connectedness.**

*...administrators got together and said, 'what do we really need? (Randy).*

In the district I studied, the characteristics of connectedness and communication were described by my research participants in regards to the district's: (a) planning amongst district administrators, (b) connectedness within the IT department (c) as an essential, technologically-supported, element of the district overall and (d) plan to encourage the communication of innovation between district teachers.

Communication and connectedness (Morrison, 2008; Cohen, Manion, & Morrison, 2007) are presented here as two required components of self-organization. The connection between these two elements is emphasized in the following excerpt:

Connectedness is *required* if a system is to survive; disturb one element in the connections and either the species or system must adapt or die; the process is inexorable. Connectedness through communication is vital. This requires a *distributed knowledge* system, in which knowledge is not centrally located in a command and control centre or in a limited set of agents (e.g. a government); rather it is dispersed, shared and circulated throughout the organization and its members. (Cohen, Manion, & Morrison, 2007, para.11)

Furthermore, Morrison (2008) explained the implications and relevance of communication and connectedness in an educational setting. He wrote:

*Connectedness*, a key feature of complexity theory, exists everywhere. In schools, children are linked to families, teachers, peers, societies and groups; teachers are linked to other teachers, other providers of education, support agencies like psychological and social services, policy-making bodies, funding bodies, the

legislature, and so on. The school is not an island, but is connected externally and internally in several ways. (p. 21)

*Connectedness in planning.*

Randy described the connectedness he witnessed in the technological planning that occurred between the district's elementary administrators. This connected planning led to the majority of classrooms in the district having a data projector and a document camera. He explained:

There were a number of meetings that happened over the years...the elementary school administrators got together and said, 'what do we really need? What's going to serve the needs of our schools?' ...There was a lot of excitement about adding technology to classrooms, and I was pleased with the way discussions went ...and their staff [members] were excited about the idea of equitably giving everybody a projector, and they were excited about the document cameras.

Further examples of connectedness are included in the feedback section of this chapter. I see the encouragement of feedback as a form of connectedness that helps an organization learn and adapt.

*Connectedness with the IT department.*

When I asked Randy if there was anything unique about his district, as compared to the other three or four in his region, he mentioned the smaller size of his district and the resulting ability to communicate and connect with people. He said this is something not always possible in a larger district. Randy explained that rather than relying on a 'ticket system', which is where all requests for assistance are submitted electronically, their technicians are also accessible by phone and email:

I think more than anything [my district] is a nice size to work in, so we've probably been able to maintain a more personal connection with people... We haven't had to rely completely on our ticket system... I'm sure in very large districts people struggle with that. In our district, all members of the IT department are accessible through email and by phone.... I think there's a personal touch that's there, and I don't think you could do it if you got much bigger than we are.

I agree with Randy's prediction that in a larger district the accessibility to technicians he described would be far more difficult. The district I worked in had almost double the number of students than his district had and we relied solely on the ticket system with occasional school-wide technological emergencies described to a technician over the phone.

In Randy's district there is one technician responsible for each of their schools. Although they are dispersed, Randy explained that his department has been encouraging connectedness within their IT department. He believes that this communication and connectedness will help with the future changes and upgrades the district is planning:

Having techs in all the buildings means...we're trying to create an environment where they all feel like they're part of a bigger group of IT staff in the district. In the future I know that when we're trying to push out something new, like a major upgrade, ... we'll be able to meet with them and lay that out. Six months before we hit a school we'll be letting them play with those things, and talk about those things, and I think that would be hard to do if you didn't have someone in the building.

The creation of a sense of belonging and communication within the tech department is an example not only of a complex system (the technicians) within the complex system of the school district; it is also an example of management creating enabling infrastructures. As Randy predicted, these enabling infrastructures will help the complex organization of the tech department to continue to self-organize, emerge and create new order so that it is able to keep pace with changing technologies and meet the needs of the school district it is nested within.

### **Communication**

#### ***Electronic communication.***

The need for secure, effective electronic communication both within the district and with parents was outlined in the district's technology plan. It stated:

The ability to communicate effectively in a school district as geographically diverse as [ours] is vital to our operations....Our long term goal is to enhance [electronic] communication between all parties involved in education: parents, students, teachers and administration in the most secure and reliable way possible. (Ferrie, 2010, p. 21)

The previous ineffective communications systems were one of the areas that Randy saw as a perturbation or problem. Before the technology was transitioned, he noted the district's email systems were not meeting user needs. He sees the new web-based email system and the easy, pervasive and fast accessibility to it as an aid to district-wide communication. Randy described the new system:

Web based email system and the interface is quite reasonable. People can check that stuff wherever they are. They can get it on their phone, they can get it on their

home computer, and you can literally walk into a room, sit down, log in, check your email.... and get back out into the hallway in less than three minutes. And that's a massive change. And when one of the biggest problems you have in your system, with any bureaucracy is communication, and if we don't have people reading their emails, or at least accessing that stuff regularly, then things don't work very well.

### *Communication of innovations*

One of the challenges that Chris acknowledged facing the district was the communication of innovative classroom-based activities. He expressed his concerns regarding whether the teachers would have the time to learn how to use the new technology with students and how to share this knowledge between teachers:

The challenge to me is the teachers, more than anything, because it's just so new and so different. Do [they] have the time to learn it? That's the part I haven't quite figured out yet, is how do we...Randy is key, and teachers like him, as a key to showing other teachers how to use this in their classrooms and that's the part that befuddles me a little bit is, now that we've got it to a place where we're happy with the technology, doing what we want it to do, now it's showing the power of it.

I see this as a significant issue for the district in terms of being a complex organization. For although the district has successfully transformed their ICT system, for them to continue to self-organize and improve educational practices utilizing this new technology, the district will need to create enabling conditions for the teachers and provide the support necessary so that the innovations can be shared amongst the teaching staff. Chris acknowledged that pockets of innovation and expertise did exist among the district's teaching staff members and in my experience these would be teachers who took

the initiative to self-teach, however Chris referred to them as contained islands because they did not have the time or opportunity to share their innovations with other teachers:

We're kind of like islands... I've noticed as I'm standing at the schools. There are huge areas of expertise, and talent and knowledge that are kind of contained to this classroom. And this particular teacher doesn't have a clue what's going on, not because they're not wanting to, but just because they're busy and you get doing your own thing and the school down the road is also doing some amazing things in a different area, and they rarely talk to each other.

He saw this lack of communication or sharing of ideas as an area in need of improvement and as one he felt he can facilitate or enable by providing teachers with release time and time for training and peer sharing. Chris explained:

I'd actually like to see, in the future, more emphasis on a couple of teachers being taken out of the classroom and being able to go and work with other teachers directly, one-on-one, in their classrooms. You know, they're not grabbing a block here or a piece of time at lunch hour or after school... we can now focus on giving teachers release time with training opportunities.

At the time of this interview with Chris, the district-wide implementation was not completed therefore future training and professional developments budgets were not finalized. Despite this, Chris shared with me his hope and vision of funding for future training and professional development. He said, "I'm hoping that the board and senior management will commit to having a budget set aside for training and professional development, but a bigger budget than we've had before. That's the hope, anyway."

## **Co-Evolution**

The term co-evolution (Milton-Kelly, 2003; Reigeluth, 2008; and Tasaka, 1999) refers to the “process ...in which each part interacts with and influences the other parts, thereby stimulating their mutual development” (Tasaka, 1999, p. 120). Reigeluth agreed and explained the concept of co-evolution in an educational setting in his statement,

For a system to be healthy, it must co-evolve with its environment: it changes in response to changes in its environment, and its environment changes in response to its changes....A K-12 educational system exists in a community and larger society that are constantly evolving. (2008, p.25)

During my interviews, the concept of co-evolution was described in terms of the district’s utilization of software that replicates Facebook, and of the ability of students to easily access the same software and files available at school, on any device outside of school. Unlike the district I worked in, which did not support any forms of social networking, I see this desire to co-evolve with students’ world outside of school as a significant attitudinal difference. This is because, as I explored in chapter two, schools have not experienced a major paradigm shift or been influenced significantly by the changes in society since the Industrial Revolution. To be clear, I am certainly not stating that the mere adoption of social networking tools will be the cause of a major paradigm shift that will revolutionize education. I do, however, see this co-evolution with society as a positive and needed first step.

### **Between society and district: Social media.**

Social networking tools (such as Facebook), although extremely popular with both teachers and students, was disallowed in the district due to concerns over privacy and

security. However, the social networking software Elgg was then utilized by the district to provide a Facebook alternative in order to meet the needs of students and teachers, thus co-evolving with popular tools in society. According to their website, “Elgg is an award-winning social networking engine, delivering the building blocks that enable businesses, schools, universities and associations to create their own fully-featured social networks and applications” (Curverider Limited, 2012, About ). As Chris explained, Elgg allows the district to provide the same features as Facebook, but with much more privacy and security. Additionally, due to the fact that this is not a medium that encourages teachers to share personal or family information, the lines between students and teachers are not likely to be blurred by “friending” as they can be on Facebook. Chris confirmed, “In this environment teachers are teachers and students are students.” To me this means that rather than utilizing a popular social media site (that may also have their personal information on it) to support teaching and learning, teachers are able to use the secure district-provided social media tool. This allows teachers and students to keep their personal lives private while utilizing a tool that provides 24/7 access to course information, assignments and collaborative opportunities. This constant access to learning opportunities was mentioned in the province’s tech plan. It stated that the province would “provide the technical infrastructure necessary to support personalized learning in schools, enabling anytime and anywhere connectivity (Province of British Columbia, 2013, para. 4). In this case, the district has already provided this anytime, anywhere connectivity through the use of the social networking engine, Elgg.

Chris explained their rationale for also providing their younger students with access to the social networking software. Not only could these students have a social

media experience, but because teachers also have access to the system they can monitor and guide student activities, thus providing guidance, when necessary, regarding appropriate on-line behaviour:

So that's Elgg... We can monitor this. We know that some parents might have some concerns about them getting on at night, but we thought we'd open it wide and let them post pictures, let them use the online chat, let them get on it 24/7, it doesn't matter to us. When they go home they continue to use the school system and that's in use constantly. There's been tens of thousands of messages posted; the kids do silly things, for sure, but... There've only been... three or four instances where students have had to be disciplined for inappropriate language or behaviour on there. Once it's addressed everybody knows you can't use that kind of language, maybe privileges will get suspended for a day or so then they are renewed again with a warning. And it's worked great.

This monitoring of ethical technology use is mentioned in "BC's Education Plan." It states, "We must make better use of technology in education so our young people will be equipped to use it effectively and ethically" (Abbott, n.d. p. 3). In my opinion, this monitoring and guiding of student's on-line behavior is a much-needed element of technology education. Just as teachers teach playground safety, appropriate playground behaviour, healthy eating and how to cross the street, we must also teach appropriate on-line behaviour and safety. While teaching Facebook safety to middle school students, I saw firsthand the need to guide appropriate and safe on-line behaviors in our students. I believe this provision of a secure district-monitored social networking site is akin to a

playground. It is a safe, monitored place for students to socialize, learn from their mistakes and learn appropriate and ethical on-line behaviours.

Chris commented on how the adults were surprised when the students continued to use this district-provided tool during the summer:

We thought that at the end of the school year kids would be told that was the end of it, but they used it all through summer and were chatting about what was happening. It was kind of an interesting way for them to communicate, even though they're not going to school anymore, and they would talk about what's happening and post pictures.

This aforementioned phenomenon of the student continuing to use a school-related tool over the summer is an example of an unpredicted or emergent use of the technology. This trend is described by Morrison (2008) as a component of self-organization:

The self-organized order emerges of itself as the result of the interaction between the organism and its environment, and new structures emerge that could not have been predicted from a knowledge of initial conditions; that emerged system is, itself, complex and cannot be reduced to those parts that gave rise to the system. (p. 21)

As with societal social media tools, such as Facebook, forums, blogs or other on-line tools, students and teachers are able to use the district-provided tools to create groups with common interests. Unlike public social media tools the district-supported groups are education-related and, as Chris asserted, the site is password-protected, therefore not only are teachers able to take part without undue concerns for propriety, the district is able to ensure students are accessing a social media tool in a safe secure environment. Lastly,

this tool has provided an enabling condition in the form of promoting a sense of ownership among its users. Chris explained:

The neat part is teachers can create groups, like a math 10 group, block A math 10, and that group could be private to just the teacher and the students who are in that particular class. Students can set up their own groups, which we've allowed... so you could have a Math 10 study buddies group which the students themselves initiate... But they've got a degree of independence that allows them to take ownership. The teachers can be part of it and not feel like there's any compromise by being on Facebook. The only access to the system is through an ID and password, so the general public can't see what's going on, but the entire school can. They can have access to what's happening, post news, events, photographs, online chat, all that.... I think it's a safe, secure, contained environment which allows a lot of freedom. Students can post documents, like PDF's, and doc files, or presentations, they can share them. They can edit documents together.

**Between school and home: Access to software.**

Unlike districts running proprietary software with licensing restrictions, in this open source software environment students are able to log on from any computer or mobile device and access the same software and files they access at school. This allows a form of co-evolution between school and home without requiring families to purchase new equipment or software. Chris described this feature and parents' reaction to it:

They have access to everything they could at school... word processing, spreadsheets, presentations. Almost all of the software is available. That's sort of a leveller of the playing field for parents too. They don't have to worry. I've had lots

of comments from parents saying, thank you, I don't have to buy software. I don't have to worry about what version of what we're doing at home is different from what's at school. Kids just go on and do it and don't even worry about it.

This access to technology that Chris described has also been discussed in literature and included in my chapter two. Pfaffman (2008), Tong (2004), Hepburn (2005) and Giza (2005) all mentioned the importance of providing all students with access to the software they need to be successful. This access alleviates financial pressure on students and families, and negates the pressure to illegally copy software.

### **Emergence: Order without Control**

*It allows you to be able to do more... (Karen)*

Emergence is, “the *process* that creates new order together with self-organisation (Mitleton-Kelly, 2003, p. 19). Reigeluth (2008) defined emergence in a similar fashion stating emergence is “a process...by which new processes and structures emerge to replace old ones in a system” (p. 27) and Davis and Sumara (2010) described the phenomenon of emergent systems, especially in education, joining to become more than the sum of their parts:

Emergent systems can join with others to give rise to even grander emergent systems. The associated image of dynamic adaptive systems nested within dynamic adaptive systems has been taken up in many domains, but is perhaps most prominently represented in education. (p. 857)

In the case I studied, I saw the emergent system of the technicians joining with the emergent systems of the schools and classrooms and the district as a whole. The changes to hardware and software were just two changes. The emergence component is and will

continue to be the processes and educational practices that emerge or arise because of the technological changes. Chris alluded to this, mentioning that although he was not knowledgeable about classrooms, he hoped that by providing educators with an enabling infrastructure in the form of accessible and reliable technology that the technology would help to advance teaching in his district. Chris said,

I can't presume to understand everything that teachers do. I'm just trying to do the best that we can with the existing technology. I'm hopeful that with Randy's leadership that's going to change. That it will change the way they teach.

In addition to the emergent situation mentioned earlier, such as when students continued to use technology over the summer, my interviewees discussed three other examples of unpredicted, emergent behaviours. These were the unexpected growth of Moodle use, the request for more computer labs and the unforeseen positive effect the addition of projectors and document cameras had on teaching and learning.

### **Moodle.**

One of the areas of emergence noted by Randy is in teachers' use of web pages on Moodle. This was a tool provided by the district during the transformation and readily adopted by teachers and students, faster than the district technology leaders anticipated. The use of Moodle was not imposed by the district, it emerged. Randy described his observations:

I think Moodle has done a lot for the people that have taken that up and I see that as an explosion. This school two years ago had five teachers who were using Moodle. This school now has every single student logged on to Moodle. ... It's growing in elementary, it's huge in middle. We've got two middle schools where if you went

into the school website and you accessed the teacher's page you're going to see yesterday's homework or you're going to see today's homework on almost all of their pages.

I believe this explosion of Moodle use observed by Randy is due to the fact that it is a tool that aids in home-school communication and provides 24/7 convenient access to course content and homework. This ubiquitous access to information is not only in keeping with the access to information in society. As a parent, I have come to expect that teachers either email home or post assignments and expectations so that they are available to peruse in the evening and on the weekends. By utilizing Moodle, this expected information is readily available to both students and parents. Pierre described that he uses his Moodle page to support what he does in the classroom - by posting his weekly dictée (French spelling tests) - and the positive response he has received from parents:

This webpage that I do is to support what I do in the classroom. .. [Kids and parents] have access to it at home... so the parents know I have a weekly dictée, which is recorded [so the children can listen to it at home]. I tell the kids, there is no reason to say you forgot it at school. They can hear the words. The parents are thanking me. [Posting the dictée] is very easy to do...I'll send an email to the parents saying that [it is there] to support their kids. It's easy for them to find.

#### **Additional computer labs.**

Once schools had had an opportunity to experience the new computer systems the district was providing, they saw an opportunity to use these machines in additional, emergent, ways. Randy described how the affordable cost of the machines prompted

schools to add even more computer labs in order to alleviate computer lab booking issues:

Because we're talking about no software costs, and ... a machine that's in the \$220 range (plus the monitor). ... Lots of people are saying... okay how much is it going to cost us to do more than the technology plan? We're going to pony up some money and we'd like to turn that room into a lab and we want to turn that room into a lab. This school has two real productivity spaces right now and they're probably going to end up with six by the time they're done ... And they're going to because ... this isn't going to be the same kind of cost as putting in a fully loaded Windows machine... So I think they're going to expand here, and a lot of the teachers' frustrations around booking will be solved by that.

I have certainly noticed, in my teaching, the dearth of available computer lab time. With more and more teaching and learning resources available on the Internet as well as society's increasing reliance on accessible Internet-based information, teachers are looking to bring their classes into the lab to do research and use productivity software more often.

#### **Teaching using technology.**

During the district's transformation process, most classrooms were equipped with document cameras, data projectors and wireless keyboards and mice. These devices were seen by the educators as having a positive influence on the way in which they taught. Although a teacher himself, Randy mentioned his surprise at the emergent behaviors resulting from this one enabling condition. He described how teachers were using the data projector and Moodle to interact with students. Randy said:

Honestly, it's still hard for me to get past [how the teachers are using] the projector, and the way that [teachers] interact with their kids. If you can interact with them that way in the classroom and then you can interact with them via the web when they're not here.

Similarly, Karen also commented on how her access to reliable technology has changed the way she teaches. She explained, "It allows you to be able to do more and ... It's changed how we access information to do the teaching that we want to do and to change how you do it with a whole group of kids." However, although Karen described how the new technology influenced *access* to the curriculum, she was quick to point out that the technology has not changed *what* teachers teach because curriculum is provincially-mandated:

I think it's affected the access to the curriculum...., The remote access--the ability to login anywhere, the ability to start something in the computer lab and finish it in your classroom, or finish it at home...in terms of getting knowledge and facts and information it's so slick, so fast. Has it changed what we teach curriculum-wise? I don't think so, because the [provincial] curriculum is the same.

This rigid curriculum may be changing in the near future. The BC's Education Plan states that, "Curriculum will be redesigned to reflect the core competencies, skills, and knowledge that students need to succeed in the 21st century... Increased flexibility will be key to making sure that student's passions and interests are realized, as well as their different and individual ways of learning" (Abbott, n.d., p.5). Whether the combination of reliable technology and a more flexible curriculum will be sufficient to produce an educational transformation or revolution in the scale Reigeluth (2008) predicts is needed

is certainly not something I can predict. However, I do think that the ubiquitous access to information described by Karen is in keeping with societal changes and is certainly an excellent first step away from the teacher-led Industrial revolution style of teaching that I see permeating classrooms that do not have access to reliable technology.

### **Fractals and Strange Attractors**

*The kids really love the system because it's their system (Chris).*

Reigeluth (2008) described fractals and strange attractors as ideals, beliefs or values that “guide or characterize the design of the new (transformed) system” (p.28). For instance, he gave the example of uniformity and top down autocratic control as fractals that characterize our current factory model of school (Reigeluth, 2008). Similarly, Mitleton-Kelly (2003) stated that, “A fractal element reflects and represents the characteristics of the whole, in the sense that similar patterns of behaviour are found at different levels” (p. 23).

In my case, the fractals discussed by my interviewees fall into the categories of empowerment/ownership, customization/differentiation, shared decision making/collaboration and lastly, the most influential strange attractor, shared values or beliefs that can be seen throughout the school district.

#### **Empowerment, ownership and freedom.**

Reigeluth (2008) described empowerment/ownership as:

Providing both the freedom to make decisions and support for making and acting on those decisions. Superintendents empower principals who empower teachers to experiment with and adopt new approaches to better meet students’ needs and to participate in school policymaking and decision making. On the classroom level the

teacher empowers each student to make decisions about how to best meet her or his needs. This form of leadership at all levels entails providing guidance and support to cultivate the ability to make good decisions and act effectively on them. (p.27)

During the transformation process, support for and overall planning of technology moved to the district level, causing an increase in the reliability and uniformity of technology. Although moving control upwards and increasing uniformity do not, at first glance, support the concepts of empowerment, ownership or freedom, at the same time this was occurring, autonomy in the form of web pages, students desktops and, in some cases, software was provided and supported. As mentioned previously, students and teachers were also given the ability to use the district social networking tools to create their own blogs and groups. This capability, along with the ability to access the district's system both from home and at school, encouraged students to feel a sense of ownership towards it. Chris explained:

We're finding the kids really love the system because it's *their* system. That's the kind of cool part, as they go home at night they still use it, they're still conversing, they're still chatting with each other, some of it's about homework, a lot of it's about personal stuff, but they really feel safe and secure that this is their system and they're being asked questions and there's learning going on, but it's in an environment that they really understand, so I think it's really successful. I'm so excited to see it blossom out to the other schools.

In the following example, Randy described how one of his programmers was empowered to experiment with and develop a software program that, in turn, allowed

teachers the option to send and parents the option to receive specific updates from their child's school:

I'm really proud of one of the little pieces that one of our programmers made, where a non-Moodle user can subscribe to a form feed. (Previously) there wasn't really a capability to give parents a way to get an email of the news that was coming out. So, one of our programmers made that happen. And now I can safely say there are examples of this in every single school in the district, there are teachers, and the school as a whole, where parents are subscribing. They're subscribing to front page news, they're subscribing to teachers homework news and class news and they're getting those messages.

Home-school communication is a vital component in ensuring student success because "family involvement that supports student learning at home is linked to improved student achievement (Allen, 2009, para 4), therefore I see this district-enabled ability of parents to sign up for class-specific updates, assignments and test dates from their children's teachers as a way of increasing family involvement and student achievement. From the standpoint of an educator, I welcome any and all methods that increase communication with and support from, my students' families for I have witnessed firsthand the difference in achievement levels between students who have parents with good communications with the school, and those without that good communication.

In another example of empowerment, the district has provided an avenue for teachers to evaluate open source software and, if it meets their needs, to request that it be installed on their school computers. To do this, Randy explained that the district has

given many of the schools an “unlocked laptop” on which teachers can download and freely trial open source software:

What we’re trying to do is we’re trying to put a Ubuntu laptop in each building ... And we’re going to put those, not into the hands of the tech, but [in the hands] of a lead teacher in technology. The person who’s most likely to say, “I’d like to have a new piece of software that does something.” In the last high school that I implemented I had enough time during the implementation to actually show them the Ubuntu software centre, and ... that it was available to them in the school and that they could go and try something on that laptop, and then follow through with some testing themselves. ... if we feel like it stands the test, if we don’t have something else that does the same job then we’re happy to put it out there. I would say that to me is the biggest thing.

### **Customization and differentiation.**

Customization/differentiation is described by Reigeluth (2008) as another form of a strange attractor and defined as the “freedom to be different” (p. 29). Although the district has been moving to a technology model that is uniform, customization and differentiation in the form of specialized software and hardware has been made available in order to meet teacher and students’ needs. The district’s technology plan acknowledged this need for customization and stated,

There are areas within our schools where the open source, thin client model may not be the best fit ... It is also important to realize that this is a hybrid model which appreciates the requirements of existing specialized software currently in place used primarily for students with special needs. Each school will be analysed and

provisioned with Windows-based system on an as-needed bases in order to ensure that the specialized software is maintained. (Ferrie, 2010, p.32)

Chris explained to me that the differentiation is not due to resistance to change, but due to the fact that there simply isn't a perfect FLOSS replacement for some of the specialty software teachers are using:

In all fairness, there is no replacement for something like Adobe Creative Suite. It doesn't exist yet... The one particular tool that maybe they're using, like VectorWorks for drafting or Creative Suite for media. There isn't a happy solution for that yet. I wouldn't say they're resistant. Until something better comes along they'll stick with that.

In terms of the proprietary software that is still being used in the district, Chris said, "We use it where we have to, and limit it where we can." He then explained that the district has also provided open source alternative software to teachers who utilize specialized Windows-based software for instruction and assignments in the hopes that, over a two year period, they will start to incorporate the open source software equivalents:

For probably a year to two years, so every secondary school we've implemented, we've said we're dual booting this lab because we know you're running Creative Suite, or whatever, however, saying that, within a two-year period we'd like to see you look at alternatives--we've put it on for you, latest versions of GIMP and Blender and things like that, we'd like you to start looking at it and see if you can integrate this into your curriculum, so that by the end of two years we're looking at transitioning off commercial packages where we can.

Randy echoed Chris's sentiments regarding allowing teachers who utilize specialty software, versus productivity software (word processing programs and presentation software), extra time to transition to open source. Randy explained it in terms of providing teachers with the extra time needed to transition to a different version of the specialized software:

I think that people deserve a certain amount of time for switching. If it's just productivity software I know that we can support that, but some of those specialty things I know that they need more time...I know they're going to have to do it themselves, and if they're going to have to do it themselves then we can't ask them to do it over Christmas holidays.

In addition to giving teachers extra time to transition, staff at the board office who utilized specialized software were also considered a customization/differentiation. Chris explained that the board office would be transitioning next, except for some staff who required specialized software:

The next step is to get the board office fitted out and moved over and I don't think there's hardly any place we won't be able to do it. The only possible barrier might be a couple of people who use really advanced functions in Excel. That could be the challenge. We might have to maintain Microsoft Office for a couple of people.

This customization or differentiation at the district office is similar to the aforementioned need for specialized software at some of the high schools. As with the specialized software needed in some educational situations, there are also some administrative functions that simply cannot be accomplished using currently available FLOSS.

The district's children with special needs and their supporting software were a third area in which customization/differentiation occurred. Pam explained that because some of the specialized software did not work on the new computer systems, students with special needs are supported through purchased cloud –based software and PC laptops.

Pam said:

I think that we're using Kurzweil so the District has bought 25 licenses to use online for those guys. And we're using Co-writer, and we're using Dragon Naturally Speaking. Those are the main ones. There is some other software; WordMaker, and that kind of stuff for the special needs kids.

#### **Shared decision making or collaboration.**

Shared decision making or collaboration is included by Reigeluth (2008) in his list of strange attractors (core ideas and values that are fairly widespread in the district). When discussing next steps for his district in terms of technology implementation and use, Chris talked about including teachers in the decision making process because, "I can't presume to understand everything that teachers do." He also mentioned that now that the technology infrastructure was operational, he would be looking to teachers, student and school administrators to guide the district's next steps. Chris explained:

The next step is just kind of what we were saying. Now that we have the infrastructure, what to do with it? ... What can we do to be really innovative ...we have the basis for it. Now I need to turn my staff toward going out and listening to teachers and students and administrators and saying, how do you want to use this system? Tell us.

I found the above statement to be an excellent example of how Chris, the district's Director of Technology, occasioned the condition to encourage the characteristics of complexity in his district. By purposefully soliciting the teachers, students and administrators for feedback and information he is encouraging self-organisation and emergence while also exploring the space of possibilities. Chris added that he believed the next steps, utilizing the now-functioning technology, was the most important, but to do this they would need to listen to the teachers, "And then we can get on to the really important stuff, which is how to use it wisely. How to help teachers with it, provide more professional development, listen to teachers and just do more with it." I agree with Chris that using the technology wisely is an important step but I also believe that his second point of listening to teachers, as mentioned previously, will ensure the district continues to evolve as a complex system.

### **Core Ideas, Values or Beliefs**

*I've become a convert now (Chris).*

Of the strange attractors, core ideas, values or beliefs are the most powerful (Reigeluth, 2008). However, "to become an effective strange attractor for the transformation of a school system, the core ideas and values (or beliefs) must become fairly widespread cultural norms among the stakeholders most involved with making the changes" (Reigeluth 2008, p 30). For example, Chris described how having the superintendent share his core beliefs was very important to the transformation process:

As far as the big issues, executive support, a superintendent that's onside, I just couldn't express enough how important that is. Our superintendent just loves this

stuff. It's his thing. He's technologically very savvy, he is so supportive, it's very humbling.

As described above by Reigeluth (2008) this sharing of values in the form of supporting the new software and hardware is an important strange attractor in a complex organization, especially among those making the changes.

### **Belief in the technology.**

One major shift in the core ideas, value or beliefs experienced by my interviewees was from knowing only a proprietary software-based environment (and at times being skeptical of FLOSS) to believing in and supporting FLOSS. For example, Chris explained that the district superintendent's rationale for being accepting of open source software was that, "he can see the moral, ethics and efficacy of open source. It just works. You know, the community builds it for the good of the community." Chris described the change in the district superintendent from having very little understanding of what open source software was to being, "a passionate zealot." This shift from having little understanding of FLOSS to being passionate about the new hardware and software is an example of a major shift in core ideas, which is another component of complexity and of a successful transformation.

Randy also experienced a shift in core ideas. He made the transition from using and teaching in a Windows environment to embracing FLOSS. In addition to working in an open source environment, he has also changed his personal home computers over to an open source software environment. Chris explained:

And I would say Randy is a zealot now, that's all he uses anymore if he can help it. He was a confirmed Windows, Microsoft user and now he doesn't have it on any of

his computers. He uses open source and he preaches the gospel to everybody and anybody, and so does our superintendent, as well. [Randy has] become the biggest fan of it. It's more than that, energy savings, cost savings, it's all being talked about now.

In addition to the shift in beliefs regarding FLOSS at the district office, the beliefs in the district overall have also shifted in that acceptance and support for the new technology are becoming widespread. For example, in response to my question regarding how district stakeholders are viewing the change Chris described the integration of the software into their district culture as well as the changes in the beliefs at the teacher level:

The executive are completely on board. They've become the zealots now, with this. It's become part of our culture now...they're already starting to preach this gospel to other trustees around the province, of how well [the new hardware and software] works. ...I talked to [a technology teacher] at [a high school] who said, "I had lots of trepidation about this and I'm a Mac and a PC guy and I'm steeped in this, and I have to tell you this [new hardware and software] works. I've become a convert now. It works so well I'm ready to start embracing other open source stuff." That's not always the case, but that's more or less what we're getting from teachers, principals, techs, students, parents, right across the board. [The new hardware and software] is not a panacea, but it works really well, and they're really surprised at how well it does work.

**Belief that technology will now always work.**

During my data collection, all of my interviewees commented, in one form or another, on the lack of reliability of the old system. I found it intriguing that they all also

commented on the reliability of the new system. I see this as an indication that the most powerful strange attractors, the core ideas, values and beliefs, have shifted from expecting technology to fail to expecting it will work. Randy commented how he believes teachers' views and expectation on the reliability of the districts' technology need to change:

You stop having expectations that it might not work and start having the expectation that it will work and I'll do what I'm going to do...I don't know that we're necessarily there, but I think that for 90 - 95% of the stuff that people do it just works. ... They know that when they go to the lab there's a very good chance that the 30 machines in there are all going to work ... 30 of them should work out of 30.

Although Randy commented on how teachers views in the reliability of the technology need to change, I think this has already started to happen. Certainly Pierre's views have. His comments on the computers were, "They don't break down, (and) they don't stop. They don't freeze. Overall, they don't break down. It's more reliable."

### **Feedback: Organizational Learning**

*I think if I had this to do all over again I would probably do it differently (Randy).*

All complex phenomena and systems have to learn, adapt and change in order to survive (Morrison, 2008, p.22). One feature I saw as assisting with this learning and adapting for survival was the utilization of feedback (Reigeluth 2008; Mitleton-Kelly, 2003; and Davis & Sumara, 2008; Morrison, 2008; and Tasaka, 1999). Both negative and positive feedback have a role in a transforming a complex system. "Negative feedback provides information about deficiencies in attaining a system's goals so that the system

can adjust its processes to overcome those deficiencies” (Reigeluth 2008, p.26). It is a regulatory form of feedback (Morrison, 2008) that “keep[s] systems in check, so that aspects do not spiral out of control” (Davis and Sumara, 2008, p. 42). Lastly, it is a “balancing, moderating, or dampening feedback (that) maintains stability in a system” (Mitleton-Kelly, 2003, p.15). Conversely, positive feedback

Provides information about opportunities for a system to change the goals that it pursues. Thus, positive feedback is information from the environment that helps a system to co-evolve with its environment. Often it takes the form of perturbances (or disturbances) that cause disequilibrium in a system” (Reigeluth 2008, p.26).

This form of feedback, “drives change” (Mitleton-Kelly, 2003, p.15) and will serve to “amplify specific qualities or dynamics that may be of use to the system (Davis and Sumara, 2008, p. 42) and it “brings increasing returns and uses information to change, grow and develop; it amplifies small changes i.e. Once a child has begun to read she is gripped by reading; she reads more and learns at an exponential rate” (Morrison 2008, p. 21).

The organizational learning or feedback discussed by my interviewees encompassed three different areas of the transformation process. Firstly, Chris described how they trialed software in a school or two and then reviewed both the software itself and the implementation, looking for both positive and negative feedback, before installing it in more schools. Secondly, Chris, Pam and Randy all commented on the overall district implementation of FLOSS and thin clients and how they would (positive feedback) or would not (negative feedback) implement the transformation differently if

they had the opportunity. Although this feedback is not of immediate importance to their district, because it will not influence the co-evolution or change its course, this negative feedback would be of importance to another district planning a FLOSS implementation. For this reason it is included here. Lastly, Chris described what he has learned (both positive and negative feedback) about funding, executive support, enabling infrastructures and the importance of shared core beliefs.

### **On software implementation.**

When we discussed the implementation of collaborative software, Chris described how the software was trialed in two schools. The district technology department then planned to review the software and the implementation, thus obtaining either positive or negative feedback, before implementing the software in more schools. Chris explained, “So we have one implementation at a middle school and one at an elementary school, with the view that we’ll review it and determine how we’ll push this out to the rest of the schools.” Positive or reinforcing feedback would drive this software change by “amplifying specific qualities or dynamics that may be of use to the system” (Davis & Sumara, 2008, p. 42). Therefore, a flawless trial implementation and positive experiences by users would be an example of positive feedback as that would drive further change. Conversely, failures in software or hardware trials or negative experiences by users would be negative feedback. This feedback would serve to “keep the system in check” (Davis & Sumara, 2008, p. 42 and “moderate or dampen change” (Mitleton-Kelly, 2003, p. 15).

**On school implementation.**

When the district technology department planned the implementation of the FLOSS and the corresponding new hardware, they decided to implement it at the elementary schools first, and then middle schools, followed by high schools and, lastly, the school board office. Chris described for me both the positive and negative feedback they have had regarding this order of implementation. The order in which the schools were transitioned to the new thin client machines running FLOSS was seen as positive (garnering positive feedback), however leaving the board office until last was received by Chris as receiving negative feedback. Chris's response to my question regarding the order of the school implementation and if he would do the same thing if he had the chance to re-do it was:

I would still do it that way, yes. Although it could be done in a different way; it could be reversed...I might do the board office somewhere sooner ... maybe during a summer, department by department. That would be something we might consider. Because the one complaint I have had is, "how come they haven't had to do this yet?" From the clerical people, "Why aren't they on Open Office yet?" I've had to field questions like that.

I also asked Pam about the implementation and if she would change anything. Although she was very positive about all other aspects of the changes, Pam's comment regarding the board office being the last to start using FLOSS was, "They should have been the first." Karen shared Pam's sentiment and explained that her rationale was based on the difficulties the secretaries were having with the different document formats and the need to convert documents from Microsoft Word to LibreOffice. Karen explained:

The board is still using Word, they'll be the last ones in the process to be done, and unfortunately the people that were first are trying to communicate with them and it's difficult. The secretaries have been frustrated because all their stuff was in Word and they're trying to convert it [to LibreOffice].

Pam and Randy both spoke about the way in which the changes (from PCs running Windows and MS Office to Thin Clients running Linux and LibreOffice) were done and they both described how, if they had a chance they would load LibreOffice software on the existing PC machines first to allow teachers and students to use this new productivity software. Following this software-only change they would then change the actual machines over to the thin clients running Linux software and with LibreOffice installed. Pam explained, "My suggestion was, why don't we put LibreOffice onto all the other computers in the schools before you do this conversion so people are already onto that, before you do the conversion. They think it's a good idea." Randy's feedback was similar to Pam's regarding the installation of LibreOffice on the existing machines before the conversion from PCs to thin client machines. However, rather than converting the school board office first, he described how he would transition the entire school district almost simultaneously. Randy explained,

I think if I had this to do all over again I would probably do it differently...I would do OpenOffice [on all of the district computers] first. I would do OpenOffice first and I would do it fast. I would go through everybody in the school district and I would do it fast. I would go, just blast through, and I would shift everybody to OpenOffice and I would offer a bunch of sessions for people who wanted extra stuff, and so I'm hitting every single school, and at the same time there's after

school sessions that are being run on particular topics, you can come and drop by, north zone, central zone, south zone, something like that, and we would move everybody to Open Office and get everybody comfortable with it and then, honestly, thin clients would be easy. Absolutely a breeze.

The approach Randy described would alleviate the challenges Chris, Karen and Pam described regarding the board office using different software than some of the schools. It would also facilitate an almost simultaneous transformation and shift in belief systems rather than having this occur gradually or piecemeal as the new software and hardware is installed in schools.

**On district-wide implementation.**

Looking for both positive and negative feedback, I asked Chris, “If you were with a district just starting to consider what you’ve done, what advice would you give them?” He responded with positive feedback on what he had learned about funding, executive support, enabling infrastructures in the form of support for the schools and the importance of shared core beliefs. Chris explained:

I have learned a lot, actually....They have to have the funding, they have to have executive support, they have to have communication, they have to have instructional support, like Randy, there has to be a Randy there. If I was doing this for [another district], I’d want the executive staff to be completely on board...I’d want enough funding to make it happen properly.

Chris emphasized the need for good support for teachers, expertise and technological support. He continued:

You'd want the instructional support through a teacher co-ordinator working closely with you. You'd want all the things that make it work, and then going out and talking to schools, which is what we did with every school. We got together, I gave presentations to the board, I did them to the executive, [and] I did them to the principals and vice principals. Talked to schools, which is when [Randy] started to take over. He would actually do the presentation. I would be his minion and sit back and nod my head. But, he becomes the spokesperson for the school, and he does it wonderfully. And then have the staff co-ordinated. Make sure the staffs are on side. Absolutely have to have the expertise to do this. In [our district] it meant hiring a computer science grad from [a local university]. And it would probably mean doing the same in [another local district] or some other place. You've got to have the staff, there's a bunch of factors.

As all of the factors Chris mentioned were in place for the transformation of his district, this list of necessary items falls into the category of positive or reinforcing feedback which, if the district was going to continue to transform, would serve to bring increasing returns and amplify these specific qualities that were of use to the transformation.

Chris described the downside, or negative feedback he received regarding a change this extensive and of the poor timing of their transformation, due to teacher job action. However, he concluded with the positive feedback and belief that what has been accomplished in his district could succeed in other districts as well:

It's no question there are cons, as well. This requires a huge commitment in the district overall. It means that there's going to be big change. But if you were to walk into [a high school] there was tons of trepidation, teachers didn't want to face

it in the middle of a job action. It was a crazy time to be doing this, but it's almost a non-issue. If it's done properly, this could be done in [another district] quite easily, I think, if there was the money and the will, it could be done.

### **Possibility of Dying**

In a complex system, the possibility of dying or complete failure of the system does exist. Davis and Sumara (2008) described this as a catastrophic collapse and stated, "Given the interdependency of agents, a significant rupture in their interactivity—such as a shift in the relational web arising from the failure or departure of an agent—presents the possibility of cascading failure and catastrophic collapse of the system. (p. 42)

Put more succinctly, Morrison (2008) wrote, "Change or Die" (p.22), but clarified and added in a more positive note that, "complexity theory is after all a theory of transformation for survival" (Morrison, 2008, p. 26).

I would surmise that if this district had not undertaken this transformation, the technological systems would have been either heading towards a complete failure (the possibility of dying) or, at the very least, a prolonged state of perturbation in which the technological systems were continually in a state of partially failing. Therefore, this undertaking, caused by disequilibrium started a transformation where management provided enabling conditions that led to self-organization and the emergence of new processes and structures to replace the failing ones in the district's technological system.

### **Creation of New Order**

In this school district, I believe I have been privileged to study a transformation leading to the creation of a new order. I have observed that, "Through the process of co-

evolution they have produced something new, a new order or coherence (Mitleton-Kelly, 2003, p.9) However, the creation of new order is not the end of change. It may well be the completion of one cycle of change, but it is important that it is not viewed as a final or unmoving condition. A complex system must continue to change because, “To survive an organisation needs to be constantly scanning the landscape and trying different strategies. An organisation may need to have in place several micro-strategies that are allowed to evolve before major resources are committed to a single strategy” (Mitleton-Kelly, 2004, p. 14). Additionally, the new pedagogical knowledge created during the transformation process needs to be shared amongst the teachers and staff in order that they, in turn, generate further knowledge thus ensuring the survival of the organization. Mitleton-Kelly (2004) explained that:

The new knowledge needs to be shared, to generate further new learning and knowledge...It is about how these characteristics of a human organisation, seen as a complex evolving system, work together to create new order and coherence, to sustain the organisation and to ensure its survival, particularly when its environment or social ecosystem is changing fast. (p. 21)

This need to explore and generate further new learning in a rapidly changing technological environment is mentioned in the next section by Chris when he described how he hopes to provide release time to enable the teachers to share their knowledge on using the new technologies with other teachers.

### **Next Steps or Continue Exploring Space of Possibilities**

*Tell us what's next for the teachers and students. (Chris)*

Complex systems do not merely experience perturbations, transform once and then experience a sense of equilibrium. A complex system needs to constantly explore its space of possibilities and evolve. Davis and Sumara (2008) explained,

For complex systems, equilibrium is death, whereas operating far-from-equilibrium forces them to explore their spaces of possibility – to tinker with new patterns of acting, to modify internal relations, and so on. Such explorations help them evolve new structures and new ways of working. (p. 81)

Mitleton-Kelly (2003) explained how this exploration of the space of possibilities needs to be encouraged and facilitated by district management by providing enabling conditions. He said:

If organisations were managed as complex evolving systems, co-evolving within a social ecosystem, emergence would be facilitated rather than inhibited, and self-organisation would be encouraged, as would exploration of the space of possibilities available to an organisation. Managers would understand that an organisation is an entity capable of creating new order, capable of re-creating itself. Management would focus on the creation of conditions that facilitate constant co-evolution within a changing environment, and would encourage the *co-creation* of new organisational form with those directly affected. (p. 23)

**Teachers' suggestions.**

One way in which the district will be exploring their space of opportunity is by looking to the teachers for ideas and guidance. Chris explained that now that the district has working infrastructure, they will be looking to teachers to find new way of supporting education using this now-functioning technology. He explained,

Now that we've got the infrastructure... We've got software and we've got hardware. It works. It requires hardly any maintenance, and it can be updated globally almost instantly. We can refresh an entire school within a half hour to move up to [a] different software version, add software, [and] change menus. It can all be done from the board office, so that part's done. The neat part is, now that we have three or four or five programmers on staff, you know as a teacher, you come along to say my vision of learning software is this... We might actually be able to make that happen now.

Continuing on a similar thread, Chris re-articulated how he is looking for feedback and ideas from teachers and students in order to keep moving forward. He said:

We've done the heavy lifting. What do you want to do with it? We've got the hard part down. Tell us what's next for the teachers and students. I think that's the part that we're really excited about more than anything... I need it articulated to me how you think that would work in the classroom ... and we can make it happen.

Because of the financial saving the district has seen due to the reliability of the hardware and software and the energy efficiency of the new technology, they have the financial ability to release teachers for training and to add to their technology-coordinator time. They also have the finances to explore future technological initiatives, thus ensuring its sustainability. Chris explained:

We don't need to spend a lot of money on the technology anymore, we can now focus on giving teachers release time with training opportunities, more co-ordinator time. That's what we're hoping for the future. That's where we're hoping this will go. The nice part about the energy savings, one of the commitments that the board

made is that since we're saving so much in energy on these devices, they said we're putting the money that was saved, rather than going back into the general budgets it's going to be set aside for future technology implementations. So ...there'll be money in a pot saved from energy savings that we'll use to refresh old systems.

### **Software.**

Once all of the schools are transitioned and operational, the district's next steps, when circling back, will be to explore possible software options to add to their system. The addition of some of the readily available FLOSS educational games is one of these possibilities. Randy predicted:

Yeah, the thing with games is an interesting one, and I think it's also something we'll spend some time looking at when we circle back, after we implement everybody. It's another conversation we can open up. The number of games in open source is huge.

### **Students' devices.**

I found that in addition to managing the district's day to day communication and technology needs, Randy also looks forward, exploring his district's space of possibility. One of the areas he has been considering was the utilization of students' phones to support educational initiatives and whether the phones could successfully integrate into the district's technological systems. Randy speculated about using cell phones to complete homework:

Some of the things [Chris] and I have talked about...I would love to see their phones...I think there's an SMS [Short Message Service which is a text messaging service found on phones and mobile devices] function, a way you can text Moodle

pages, so it would be very cool if students, one day, could make a forum post.

They could do a forum post for homework with their phone. I think that would be cool. Lots of teachers, we talked about paperless assignments in Moodle, one of the things that you can also do, and I've seen teachers doing this all the way down to grade 2, is creating a special forum on a special topic.

In this chapter, I utilized the characteristics of complexity theory to present and interpret my findings. These characteristics were: self-organization, co-evolution, emergence, fractals, core ideas, feedback, the possibility of dying and creation of new order. Using these characteristics I described and explored the transformation of the technological systems in a school district.

This transformation was caused by perturbation and disequilibrium in the form of dysfunctional technological systems and occurred through a process of emergence in which an enabling infrastructure, self-organization and co-evolution resulted in new technological processes, equipment and software to replace the old system. In addition to the new processes and equipment, the complex system experienced a critical shift in core ideas and beliefs concerning their technology. They shifted from a belief that the technology was unreliable and outdated to one that saw technology as reliable, sustainable and able to adapt in order to meet both current and future needs of the district.

In the next chapter I provide an analysis of the finding presented in this chapter. This analysis includes the three main themes that emerged for me during research. They are: (1) the challenge districts face in "keeping up" with technological changes; (2) the importance of the provision of enabling infrastructures both during a change process and

to encourage complexity and; (3) the critical role leadership plays in addressing the first two themes.

## Chapter 5 - Themes

While conducting this research and reviewing the results, I found there were three main themes that emerged. The first theme pertains to the challenge of “keeping up” in a time of perpetual change in educational technology. This challenge includes, but also goes beyond the financial aspects of schools and districts affording current technologies to support education to encompass teachers’ and students’ attitudes and the connection between emerging technologies and changes in pedagogy. I don’t believe this challenge to keep up can ever be met by top-down government programs or mandates. The innovations to keep up will emerge from educational leaders, teachers and staff throughout our province.

For these innovations to be possible, my second theme needs to be addressed. It is the provision of enabling infrastructures to encourage and support new ideas and practices to emerge as well as a means for teachers, staff and students to provide meaningful and utilized feedback on these changes and innovations. My third and final theme concerns educational leaders and how their leadership is crucial in addressing my first two themes. It is district leaders who will either make the decisions to keep up with the changings needs and technologies in education or to merely manage the status quo. These leaders will both provide enabling infrastructures and encourage emergence and meaningful feedback or they will utilize top-down mandates with little or no opportunity for feedback or for innovations to emerge or be shared. Throughout this chapter, I utilize examples from my research and my experiences as a classroom and computer lab teacher to illustrate the phenomenal impact district educational leaders can have on these important aspects of technology and educational change.

### **Challenge of ‘Keeping Up’**

Society’s use of technology is constantly changing and adapting. With this change outside of the school community comes a pressure on education to “keep up” with society and to utilize technological tools that are popular outside of school, within schools. This “keeping up” is also referred to as “co-evolution” (Reigeluth, 2008; Mitleton–Kelly, 2003) and occurs when a system (such as a school district) changes in response to changes in society. This challenge to keep up involves not only the technology itself, but also the knowledge and ability to utilize these technologies in an educational setting. As I discussed in chapter 2, Reigeluth predicts that not only will the pressure to keep up continue, but because “society has been changing in such dramatic ways ... we need a new educational system that is as different from our current system as the automobile and airplane are from the railroad” (1994, p 5). This new educational system that Reigeluth describes will not be realized if education does not keep up with society; education will instead remain as an outdated failing system based on an Industrial Revolution mindset.

### **Technology**

Ensuring that the technology in a district is current, sustainable and meeting the needs of users is a never-ending challenge for district leaders. When this challenge is not met, for instance if the technology has become outdated, leaders need to openly acknowledge the technological problems their district is experiencing. The acknowledgement of these problems (also known as constraints or perturbances) will then allow the district to “explore its space of possibilities” or investigate possible solutions to the problems. In the district I studied, the constraints were acknowledged when the superintendent’s team sought to hire a Director of Information Technology and

again, much more clearly, when that new director authored a technology plan that outlined the districts' inadequate technological systems. The district technology plan stated:

Perhaps the greatest challenge we face is the degradation of our computer hardware pool, the aging of our software resources and the need to keep current with modern technologies....our primary operating system and productivity package [are] 7 years old with no plans to upgrade.

Consequently technology resources for our children will continue to get more dated as time progresses. (Ferrie, 2010, p.5)

This acknowledgement is an important first step and one that opens lines of communications between district staff and therefore emergence in a district. When teachers and staff know that district leaders are not only also aware but are trying to help solve a problem they are more likely to be supportive of any changes. Certainly, all of my interviewees spoke positively of the changes and the change process they experienced.

Conversely, when a district refuses to acknowledge district-wide technological problems or constraints, I have seen teachers withdraw to their own insular classrooms and make do the best they can, often bringing in resources such as computers and cameras from their own homes. One example of a problem not acknowledged in the district I worked in, unlike in the district I studied, is the obsolete technology and the lack of a district technology plan: As a teacher working daily in a computer lab, I received no acknowledgement by districts leaders that the technology was old, that the technicians were overworked or that teacher and student needs were not being met. Not only was there no district technology plan, technological funding and support was decentralized

with any piecemeal changes made by individual principals and schools. In the school I worked at the principal made the decision to spend technology funding primarily on SmartBoards. Because almost all funding was directed towards installing a few SmartBoards every year, over the last four years students' classroom computers and school cameras have become so old they are unusable and, ironically, teacher computers were found to be inadequate to run the new SmartBoard software. This lack of foresight in technological planning could have been avoided if the district had acknowledged the problem of the ageing student computers and, instead of permitting decentralized purchasing of unsustainable technology that does not support 21<sup>st</sup> century learning and teaching, begun district-wide planning for sustainable and reliable technology for students and teachers. This was the approach taken by the district I studied: Rather than ignoring their ageing technology and encouraging the decentralized and unsustainable purchases of technology that does not support 21<sup>st</sup> century learning and teaching, the district leaders acknowledged their technological problems, explored their options and developed a long-term sustainable plan for their district.

The utilization of Free/Libre Open Source Software (FLOSS) is another example of how the district I studied is able to keep up with changes. Not only can all the software be easily updated for free whenever new software is available, students and teachers can log in from home and see all of their school-based files and the updated software. This includes the ability of teachers to be able to access student report cards and reporting software. This provision of pervasive access to school information is keeping up with the expectations of students and teachers as it mirrors their access to information that they have out of school. Again this is a very different situation from the district I worked in

where the operating system and Office software was almost 10 years old, hardware was unsustainable and we had no access to our school files or software outside of school.

### **Connecting current popular technologies with pedagogy**

By providing students and teachers with access to software programs such as social media, websites and information feeds that are popular outside of school from within the school district, the district supported the development of new pedagogies that integrated these popular tools and supported new ways of connecting teaching and learning. For example, Pierre spoke of accessing web cams in Ottawa when his class was studying Ottawa and Karen had her students access on-line weather station websites to gather information and the share their understanding of their findings on a class forum.

In addition to students and teachers having access to this social media software both at school and outside of school, they also had outside-of-school access to the software and files that students in my district only have access to while they are physically at school. This access then enabled students to not only interact with their teachers and each other outside of school, but it provides current pervasive access to all of their in-school software and files. While I can't predict whether this 24/7 access to education resources will change pedagogies, I do know from watching my own children that it gives them the freedom to complete assignments at a time and place that they prefer.

As discussed in my previous chapter, the social media and communication tools are also being utilized by teachers and students to support learning through the creation of subject groups, such as "grade 10 math", by teachers posting assignment and support materials and by parents accessing school and classroom information feeds in order to

stay informed about relevant events. Students are also exposed to social media software in a safe and secure environment in which they can learn about appropriate on-line behaviors. I think this last point is an increasingly important teaching opportunity given the recent occurrences in the news of teens posting inappropriate material on-line and the resulting unfortunate outcomes such as extreme embarrassment and even suicides. I fully believe that if these teens had been exposed to supervised social media when they were younger, appropriate on-line behaviours would have been taught and learned and possibly some of these unfortunate and disturbing on-line behaviours would have been prevented.

In stark contrast to this example of how the district I studied kept up by providing secure social media software, and 24/7 pervasive access to their at-school software and files, neither the students at my previous school or I had access to any secure and district-provided social media, communication or collaborative software. They also did not have access to school files (unless files were saved on portable drives or emailed) or software when not at school. Teachers even needed to carry electronic report cards back and forth between school and home on a USB drive because there was no access to school files from outside of school. I think this lack of access to resources is an example of how my previous district has failed to keep up with both changes in and expectations of society because in school-related matters teachers and students do not have the ubiquitous access to information they have come to expect based on their outside-of-school experiences. As compared to students who do have this 24/7 access to school work and school software, I think this lack of access puts my students at an educational disadvantage as it is much more difficult for them to bring their technology-based projects into their homes to share with their family or to work on. Additionally, because

student in my previous district were only able to access school resources while they were physically at school they did not have access to subject-level peer support or collaborative projects during their out of school time. Lastly, parents had limited access to at-school news and updates (they were often still paper-based) and there was no opportunity for me to teach increasingly important social media behaviours to my students.

### **Providing Enabling Infrastructures**

The importance of district technology leaders ensuring the provision of the conditions and infrastructures that encourage new ideas and practices to emerge as well as the means and opportunities for teachers, staff and students to provide meaningful and utilized feedback on technological changes and innovations is the second theme that emerged for me. The provision of these enabling environments must originate from district educational leaders, and be further supported by management throughout an educational system or district.

### **People's attitudes**

One of the characteristics that stood out for me in the district I studied was how positive my participants were when they spoke about the newly implemented technology. Not only did my participants speak positively about the changes to the technology itself, but, as Karen said, "everything works, and works at the same time." They also spoke positively about the people supporting the technology and the change process. For instance Karen further commented, "We have such good support. I cannot say enough about it." The fostering of these relationships was supported through the facilitation of meaningful feedback, positive changes based on this feedback as well as the provision of

timely and adequate technological support during this change process. Additionally, I think that by providing teachers with an additional piece of educational technology hardware also contributed to this positive attitude. For example, in addition to the excellent support and changing the technology so that it was now reliable, many classroom teachers were also provided with a data projector and wireless keyboards and mice. Although Pierre did not see the immediate benefit to the new computers, “I mean for an elementary, how will that help? All I saw was an administration tool” he certainly appreciated the corresponding new document camera and data projector. He said, “I must say that since getting the projector a year ago it has made it more relevant... more applicable to the classroom, to what I do.” Pierre also commented on how the projector has improved his students’ access to information. He explained, “Everyone that goes on the projector is doing something that allows everyone to participate. That’s what I find. I have books and books on some of this, but to go on the computer is much quicker and easier.” To me, this was an example of how, by adding additional educational technology hardware during a technological transformation it contributed to the positive attitude of those experiencing the change. Although this may seem akin to a form of bribery, I see it as sound change management as the devices provided were not out of the range of the standard in BC classrooms and, as described above, they significantly added to the positive use of technology in the classrooms in this district.

### **Feedback is critical**

The building of positive relationships and connectedness through communication networks and feedback mechanisms are vital characteristics of complex educational systems that can be supported by effective district leaders. Feedback (Reigeluth, 2008;

Mitleton-Kelly, 2003; Davis & Sumara, 2008; Morrison, 2008) is a characteristic of a complex system and provides information about the challenges in meeting a goal (negative feedback) or in opportunities or successes when trying to meet this goal (positive feedback). Although I don't believe it is always necessary or useful to utilize these binary categories of feedback, they are included here because they are mentioned as part of complexity theory. Meaningful feedback from software and hardware trials or pilot programs not only contributes to the success of an educational innovation it also encourages support and communication from the teachers and students experiencing the changes.

The district I studied trialed the planned district-wide software and hardware systems in one elementary school, received feedback on this trial, and then significantly changed their approach before implementing these changes in other schools. As described below, as a result of this trial and the feedback from school staff the planned software implementation was completely revised which contributed to the success of future innovations. Additionally, the district leaders were completely upfront about their successes and failures during this process: There was no attempt to hide failures, they simply changed their approach and the software and tried again. My conversation with Randy, the District Technology Co-Ordinator outlines this trial-feedback and re-trial process:

Year one we did [a new elementary school] and that was the only school we [trialed] that year.... they were a brand new school. There was a bunch of challenges around doing a brand new school, but they walked in to their brand new school on day one with Linux open source....Made a bunch of

mistakes, and there were some challenges there....Two days before school started there were 3,000 boxes [of teachers' classroom supplies] in the hallway. So needless to say it was complete upheaval. They were in upheaval already; they didn't need us to do anything....So that was a challenge.

Although it had seemed to be a sound plan to start implementing the new hardware and software in a new school, as Randy explained above the additional “upheaval” or disruption with moving teachers and their supplies into their new school and classrooms, in addition to implementing new hardware and software, was an unanticipated challenge to both the district technicians and the teachers. When I asked Randy how he would approach this trial differently if he had the opportunity, he responded:

I wouldn't pick a brand new school. I would pick a staff. I would pick a school where I thought I had a good tech, and a reasonably receptive staff, and I would go in as much as I could and show them what they were going to get. I would make sure that we had the server up with at least a desktop that I could show them before we started---this is what it looks like.

He agreed that when changing out the computer systems in a school that should be the only change the school experiences, not a new staff, classrooms, students and school as well. From a teacher's perspective, I see his reasoning as sound. For a teacher, moving schools is akin to moving houses – often with nearly as many boxes! Not only do they have to set-up a new learning environment for new students, they also had to learn new routines, procedures, co-workers and supply locations. It is a stressful change that would only be exacerbated by a change in technology as well.

Randy also discussed the learning process and unexpected difficulties he experienced as well as the stress teachers experienced due to the change in software programs:

This was a learning process for all of us, too, so I made the foolish assumption that lots of this stuff was going to work, it was just going to work and there wasn't going to be the transfer, that legacy switch from the old stuff to the new stuff. I didn't really realize how many problems...from Windows to Linux. Just little things that cause people stress, like the font that you use to make that does not exist in this system. Or the font looks like it exists but it's a different size. Arial narrow font in Linux is a different size than Arial narrow font in Windows.

The feedback Randy received and acknowledged helped him to prepare other schools transitioning to open source software. For example, in the school session I attended, Randy advised teachers who wanted to utilize important documents on the new system to first save them in .doc (not ODT) format if they needed to edit them in the future and as a .pdf file if they wanted to keep, but not edit the document.

In addition to unexpected difficulties with software and fonts, and the stress this caused for users, Randy explained how they needed to change their plan based on the feedback and needs of teachers and students. He explained how rather than changing every machine in the school to the new Thin Clients (computers) running Free/Libre Open Source Software (FLOSS), they needed to leave one Windows machine in certain classrooms so that students with special needs had access to Kurzweil (special needs software):

I don't think we realized how much student services stuff they were going to have and how much of it we weren't going to be able to do on Thin Clients. Most of us went in naively thinking we were going to do a 95 - 98% conversion [of the computer systems] and that was just not going to happen. We also were surprised by the fact that [the teachers] wanted to have a program like Kurzweil in every single classroom in the school. Well, where Chris came from they had a room where they put the Kurzweil machines, and suddenly they want de-centralization of that, well that means that one of your computers in every single classroom has to be a Windows machine. So, yeah, there were piles of things we needed to do differently. So that year I spent months in that school, working with that staff.....Learning tons.

In keeping with the district's managerial preference for utilizing feedback and experiences to develop improvements, Randy explained how the district eventually changed their originally planned operating system from KDE to Ubuntu (two different FLOSS operating systems) based on feedback and user needs, and then ran a second installation, which was a second pilot (trial) installation at another school. Randy said:

We decided that the following year we were going to go and do all the elementary schools that year. So we did it...We went to Ubuntu. Eventually we threw the pilot away and started all over again.... [Another elementary school] was the next school, and they got pilot status.

Following this second pilot or trial and during the three-year transition process the district technology team also re-visited previously transitioned schools to upgrade the existing Ubuntu operating system. This circling back or re-visiting is an important aspect of

feedback and a characteristic of a complex system. Randy explained the process the district followed:

They became the [second] pilot, and we went through all the elementary schools on Ubuntu. That was Ubuntu 9.04 and so since then we have also circled back---by the time we finished the second middle school it was time to go to Ubuntu 10.04, and so we finished the second one and then we circled back through all the elementary---eight elementary ... and the two middle schools and put them all on 10.04, then did the last middle on 10.04, and then this year started on the high schools.

Although the software and hardware trials, and feedback from the trials, took time and resources on the part of the district, these are critical components of successful change as they allowed the district leaders to develop a better product that was better able to meet the needs of students and teachers in their district. Without these elements of connectedness, communication and feedback loops knowledge would have remained centrally located and distributed in top-down manners with no ability to change and adapt in order to meet the needs of users.

Unfortunately, a lack of connectedness, communication and feedback loops has been the case in some government-initiated programs. For instance, the currently proposed Digital Literacy Standards in British Columbia opened for comments October 2012. The website states:

One of the things we've been working on lately is a set of digital literacy standards for students. These standards identify the skills and knowledge students need to be successful in our increasingly digital world. Please review

our draft standards and let us know what you think. Are we on the right track?

Any other suggestions? (Province of British Columbia, 2012, Developing Digital Literacy Standards).

At first glance, the above request for suggestions on the draft standards appear as though communication and feedback were being enabled through the use of an Internet-based discussion forum, however this is merely an illusion. When a question was posed regarding the timeline for the implementation of the proposed standards, the response was “the standards you see on the site have pretty well been settled on” (Moderator Mike, Jan 2013). If the proposed standards were posted for feedback in October, in January they were settled on and in April 2013 they are still available for feedback, then no feedback was actually ever going to be incorporated – then the forum must be no more than an illusion of the creation of connectedness. In reality it appears to be merely a means of only communicating top-down decisions. This antiquated form of management is in keeping with an industrial age form of education and has no place, in my view, in the planning of 21<sup>st</sup> century education.

In order to enable transformation in education, connectedness through reliable communication is required as well as meaningful mechanisms for feedback. If an innovation is trialed and feedback is requested, it must be valued and incorporated. Additionally, if changes are made based on this meaningful feedback, the changes also need to be communicated so that participants are further encouraged to participate in information sharing and self-organization. This was the case in the previously-explained district-led pilots: The initial pilots did not meet student and teacher need; this feedback was given and received and then the district responded and changed the technology plan.

This is certainly does not appear to be the case with the BC Government's request for feedback on its new Digital Literacy Standards.

Some educational leaders need to realize that teachers are not easily duped through sham feedback forums on pre-decided standards or changes. In order to transform education so that it can meet the needs of students and teachers in the information age, positive relationships in the form of meaningful communication and feedback between educational leaders, teachers and school staff concerning all manner of educational change must be a priority of educational leaders.

### **Supportive technology.**

The utilization of technology that supports complexivist ideals and behaviours is an important managerial decision. Free/Libre Open Source Software (FLOSS) supports and encourages complexity in education because FLOSS itself is a complex system developed by a group of people from all over the world who develop and evolve this software based on perturbances and feedback. Therefore the utilization of FLOSS in education would be nesting complex educational resources within another complex system. Davis and Sumara (2010) believed this will lead to a much grander system:

Emergent systems can join with others to give rise to even grander emergent systems. The associated image of dynamic adaptive systems nested within dynamic adaptive systems has been taken up in many domains, but is perhaps most prominently represented in education. (p. 857)

The nesting that Davis and Sumara describe does not just happen between software and educational practices, there are many different conjoined complex systems that influence each other and together make up the complex system we call public

education. As I discussed in chapter 2, Morrison (2008) gave examples of these nested systems. He described the connections in education as:

Children are linked to families, teachers, peers, societies and groups; teachers are linked to other teachers, support agencies . . . , policy-making bodies, funding bodies, the state legislature, and so on. The child (indeed the school) is not an island, but is connected externally and internally in several ways. (p. 20)

Due to these nested and co-entangled properties of public education, when educational technology leaders make decisions regarding the type of technology to be used in their schools and district, it is important that these moral, ethical and pedagogical decisions are made based on 21<sup>st</sup> century educational goals, not on traditional top-down Industrial revolution styles of thinking, teaching and managing because their decisions will influence and impact the other related systems. For example, as discussed previously these technological decisions can have a financial impact on families as well as determining how and when students, teachers and parents access information and software and influence how and if technological tools are utilized in teaching and learning. Also, I see the utilization of proprietary software within complex co-evolving educational systems as akin to the utilization of standardized testing and rote memorization – they are not approaches that support or encourage emergent thinking and collaboration. Just as standardized testing and rote memorization discourage collaboration, cooperation and the open sharing of ideas and advancements, so does the utilization of proprietary software. Conversely, FLOSS encourages and supports the values of collaboration, cooperation and the open sharing of ideas that are so valuable to

21<sup>st</sup> century learning. Additionally, in the development of FLOSS, as with any complex system, there is the possibility of a project, or a portion of a project dying because it is no longer needed or relevant to society. This is unlike some proprietary software or hardware where companies continue to promote outdated technologies that support Behaviorism and Industrial Revolution styles of teaching (such as SmartBoards) in order to make a profit.

FLOSS also has the ability to display emergence or unpredicted structures to replace the old ones and shared core ideas or values throughout the FLOSS community. These values of the importance of co-operating, collaborating and sharing knowledge are the strongest strange attractors shared between FLOSS and 21<sup>st</sup> century educational objectives and my rationale for investigating, through my research, whether FLOSS is the better choice for education than proprietary software.

### **Leadership is Critical**

District leaders play a critical role in managing change and creating the conditions for the characteristics of complexity to flourish. In the district I studied, the creation of these positive conditions entailed significant financial and time commitments because many of the technological systems in the districts were out of date. This is also the case throughout Canada. The results from the “Information and Communications Technologies in Schools Survey by Plante and Beattie (2004) found that, “only 23% of the elementary and secondary schools in Canada had the majority of their computers running on the most recent operating systems (p. 12). From my observations, this number is even lower today (and it was lower in the district I studied) because over the last decade I have seen increasing cuts to education and technology funding and the

management of failing educational technology becoming the norm. Despite these challenges, district leaders in the district I studied were able to create the conditions that encouraged complexity. Mitleton-Kelly (2003), Founder Director of the Complexity Research Programme at the London School of Economics, described the importance of the managerial understanding and behaviours:

If organisations were managed as complex evolving systems, co-evolving within a social ecosystem, emergence would be facilitated rather than inhibited, and self-organisation would be encouraged, as would exploration of the space of possibilities available to an organisation. Managers would understand that an organisation is an entity capable of creating new order, capable of re-creating itself. Management would focus on the creation of conditions that facilitate constant co-evolution within a changing environment, and would encourage the *co-creation* of new organisational form with those directly affected. (p. 23)

I see this emergence that Mitleton-Kelly described as one of the most important and overarching themes due to the constantly evolving nature of technology. Technology will continue to change and adapt, therefore it is important to have leaders of technology and of education that are able to successfully manage this change in their districts so that the districts can also change and adapt to meet changing student and teacher needs.

**Adaptability is important.**

Educational leaders who possess a thorough knowledge of the processes of change and the ability to adapt any planned change in order to meet the needs of teachers and students can provide the conditions that enable transformation in their district. However, it is important for educational leaders to realize that as their organization/district

undergoes a transformation, the transformation process itself must also be able to adapt or transform. This avoids the attempted implementation of a one-size fits all outlook, for no matter how perfect the plan appears, all changes to a complex system must have the ability to transform and adapt (based on feedback loops) during the planning or implementation processes. This adaptation may occur when re-using an innovation from another district, such as when Chris brought his knowledge and experiences from one district to his current one. In this instance Chris explained to me how he had made mistakes during this first transition, he learned from them, studied the technology further and revised his approach, thus experiencing adaptation before attempting another transformation in another district. However, even his new revised approach needed to be adapted further because (as explained previously by Randy) the software and approach used in Chris' previous district did not meet student and teacher needs in his current district. Additionally, changes were required because customization between schools and classrooms was needed so that teacher and student needs could be met.

This ability to transform the transformation contributes to the overall strength of the complexity in the district. This observation was partially shared by Morrison (2008) who commented that “all complex phenomena and systems have to learn, adapt and change in order to survive” (p. 22). Change is not stagnant for the change itself must also adapt and change making an infinite loop out of the ‘adapt and change’ process. As discussed in my next section, in addition to the change process changing, the district leaders also shifted their focus from the provision of reliable and sustainable technology to the provisions of conditions that encourage the sharing of knowledge between teachers regarding the utilization of the new technology for teaching and learning.

**Create opportunities for new ideas to emerge and to be shared.**

Designing conditions and providing enabling infrastructures that encourage the creation of knowledge as well as the sharing of that knowledge are important skills and aptitudes/attitudes for district leaders enabling complex change. This is not a common occurrence as, “Most schools are not good at knowledge sharing within their own walls, let alone across schools in the same district” (Fullan, 2001, p.104). Providing the conditions for emergence to be enabled is one method of accomplishing this, especially when the district encourages connecting, communication and feedback loops by providing opportunities for these emergent practices to be shared amongst teachers and staff.

During my research, I was able to observe the development of opportunities for emergence as well as exploration of space of possibilities that could lead to the development of new knowledge and practices. Emergence was encouraged through the provision of accessible, reliable and customizable technology. The district’s plan was to provide teachers and students with pervasive access (access from everywhere such as home, school, and mobile devices) to these technological tools in order to create an environment that encouraged the exploration of possibilities and enabled emergence. For example, once all of the technology is operational, district leaders plan to look to the users of the technology for emergent ideas and goals. Chris, the Director of Information Technology, explained:

Now that we have the infrastructure, what to do with it....Now I need to turn my staff toward going out and listening to teachers and students and administrators and saying, how do you want to use this system? Tell us.

This approach was also described in Fullan's (2013) book "Stratosphere: Integrating Technology, Pedagogy and Change Knowledge." He described the importance of the teacher's role as an agent of change. He stated, "The teachers as a change agent is crucial... The skills of teacher as change agent are now known" (p. 67).

One example of my observations of the exploration of possibilities was when Randy described how he had been thinking about having students utilize their cell phones for accessing Moodle (a web page) and posting homework and discussions to it. He described to me how he had talked the idea over with teachers and they had discussed not only the possibility of using this capability of posting comments on a certain topic, but doing so with students as young as grade two:

It would be very cool if students, one day, could make a forum post [a post on a website]. They could do a forum post for homework with their phone. I think that would be cool. Lots of teachers, we talked about paperless assignments in Moodle. One of the things that you can also do, and I've seen teachers doing this all the way down to grade 2, is creating a special forum on a special topic. (Randy)

Enabling the conditions for emergence is a key component of a complex system, for it is through emergence, a process by which "new processes and structures emerge to replace old ones in a system" (Reigeluth, 2008, p. 27) that educational transformation can occur. As described in a previous chapter, the emergence I saw in the district I studied was not brought about by legislation or other top-down initiatives originating from outside the district, but was instigated by the leaders within the school district, for the good of their own district. Although there was an element of top-down change in terms of

the choice of the technology itself and the implementation process, the elements of feedback, trials, customization and adaptations diminish or negate, from my perspective, the negative aspects of a top-down initiative. Additionally, the district plans to continue providing the conditions for emergence by funding release time for teachers so that teachers in the district can share teaching innovations with other district teachers. I see this as a positive initiative, for in my experience many district-supported educational initiatives are led by representatives from textbook or software companies not familiar with the unique aspects of the district (and are perhaps more business-minded than student-minded), thus making the initiatives yet another a top-down one-size-fits-all initiative. These top-down initiatives, no matter how well-intentioned, only serve to prevent the needed paradigm shifts in education described by Reigeluth (1994) and inhibit the “search for a system dynamic enough to complement the new realities of the Knowledge Age” (deWaard, 2011, p. 94). As described above, because district leaders encouraged and supported the exploration of possibilities, the district has the ability to be more dynamic. I see this as an example of the ability of a district, with appropriate leadership, to adapt and change in order to change to meet the ever-changing needs of their students, without outside government orders or direction.

### **Support.**

Self-organization is another characteristic of complexity that can be supported and encouraged by district leaders. In the district I studied self-organization was evident through management’s provision of enabling infrastructures or support. These included adequate funding to support the technology plan and in the provision of ample training and support for teachers and staff. One example of this understanding of the training and

support required was outlined in the district's technology plan. It stated, "Technology initiatives will fail unless they are supported with effective, ongoing maintenance, technical support, and staff development. The general rule of thumb is that schools should allocate 30 percent of their technology budget to training and professional development" (Ferrie, 2010, p. 8).

### **Coherence.**

Coherence (Davis and Sumara, 2008; Mitleton-Kelly, 2003 and Tasaka, 1999) is the sameness that allows an organization to become more than the sum of its parts. Davis and Sumara (2008) describe coherence as tied to this sameness or commonality. They said, "A complex system's capacity to maintain coherence is tied to the deep commonalities of its agents" (p. 39) and then in 2013 they further described coherence as a sameness that allows a group or organization to become more than the sum of their individual parts. They said:

Complexity thinking is devoted to making sense of the emergence of coherences that transcend the agents they comprise – in the way that ant colonies include but exceed the ants that populate them, brains emerge, but are more than the networked activities of neurons, and nations arise from, but can no way be reduced to, individual citizens. (xix)

I found this coherence when I looked at how the district executive worked as a team and were enthusiastic about the both the changes and the new technology. For example, when discussing the district leaders Chris said, "The executive are completely on board, they've become the zealots now with this. It's become part of our culture ....they're already starting to preach this gospel to other trustees around the province, of how well it

works.” In addition to being an example of cohesiveness within the district leadership, it is also an example of positive feedback in that as their district continues to experience success in their initiative, they are more likely to continue to support their own initiatives and encourage other to do the same.

Communication and connectedness were encouraged during planning and implementation and will continue to be encouraged by managers. The characteristics of district leaders that I observed and that encourage cohesiveness and self-organization include: leaders worked as a supportive team, communicated and connected with each other and provided adequate funding, training and support to the remainder of the district team, thus ensuring the success of initiatives. Although these characteristics displayed do not appear, from my observations, to be onerous or more than should be expected of a leadership team, in my experience it is often not the approach taken. For example, unlike the district I studied, my school board does not appear to function as a cohesive team. They were bitterly divided over many issues including budgeting, transparency of meetings, Wi-Fi in schools and a conflict of interest appointment to the Safety of Wi-Fi committee. In this environment a team or cohesive approach appears challenging, as is evident in the dearth of team support. Additionally, district managers did not provide enabling infrastructures in the form of communication of innovations (although the teachers` union has a yearly professional development day for this purpose), district technological support is nearly impossible (my school had over 200 hundred computers, 600 students and a technician only ½ a day each week) and, aside from commercial SmartBoards training, I did not notice, nor found on the district website, any recent district-provided technological training or initiatives.

Educational leaders play a large role in the formation of cohesion in the basic values and beliefs in a school district. These “strange attractors”, i.e., something that has a “powerful influence over the processes and structures that emerge in a system undergoing transformation” (Reigeluth, 2008, p. 27) can be encouraged by educational leaders through the empowerment of their staff, encouraging shared decision-making and collaboration, and the acceptance of customization/differentiation. As described by Chris in a previous chapter, these characteristics were encouraged in my case by providing students and teachers with customizable social media tools that allowed teachers and students to create their own groups and meetings such as a grade 10 math group or another subject-specific study buddies group. This ability to customize the district-provided tools encouraged the formation of collaborative groups to assist with homework or studying, or to provide a safe social setting within the confines of the school district, in which students could interact and share digital media.

Leadership was also crucial in the support of the customization or differentiation, through the provision of customizable websites, encouraging innovations in software development, allowing teachers to trial and request new software, and providing (different from the norm) specialized software to meet student and teacher needs. For example, when describing the customization in software in order to meet user needs Randy explained, “There are probably a few extra Windows machines in this district because of me, because I’m trying not to make people’s heads explode.” Although at first glance, this can be taken as a humorous statement, however, it is a testament to management’s desire to allow teachers and staff to customize the technology in order to provide teachers and students with suitable technological tools during a time of change.

By leaving the Windows machines in place for longer than the district had originally anticipated, thus not forcing a difficult and immediate change, Randy allowed for a greater length of time to transition to the new technology, therefore reducing teacher stress and the possibility of “heads exploding.”

These and the other aforementioned enabling managerial behaviours support the development of shared core ideas and beliefs. In the case I studied this was that the technology will work, that teachers will receive support if they need it, and that management cares about maintaining functioning technological systems that meet the needs of teachers and students. This situation is diametrically opposed to the one I worked in where there were no district-provided social media tools or websites available for teachers and students to adapt to meet their need, the technicians were too busy maintaining a failing system to develop innovative software tools to support educational practices, and teachers were not permitted to install any trial software on school computers. Therefore the educational leaders in my former district had not created an environment where staff felt empowered, where emergence was likely or where there was cohesiveness. Rather, the overall shared beliefs that I witnessed and experienced in my former district was that some of the computers will always fail, timely district support is not available and district management is not concerned with either maintaining classroom or school computers for students and teachers or encouraging innovative uses of technology.

These three main themes that emerged for me over the course of this research were the importance of and the challenges to “keeping up” in a time of perpetual change in educational technology, the impact of providing enabling infrastructures so that new

ideas and practices can emerge to keep pace with these changes and lastly, the crucial role that leaders of educational technology play in either accomplishing little more than managing the status quo or meeting the challenges of keeping up in our changing times.

The significance of these three themes becomes even greater when observed from the standpoint of connecting a vision of what 21<sup>st</sup> century learning might look like (Prensky, 2008 and Davis, Sumara & Luce-Kapler, 2008) the current regulations, plans and practices leaders are utilizing to reach these goals. Although the province of British Columbia, and I am certain some school districts as well, have plans and regulations in place to upgrade their technologies in order to try and “meet 21<sup>st</sup> century learning objectives”, this alone is not enough. As shown through Chris’ comments, educational leaders need to do more than “just put boxes, used boxes on teachers’ desks.” They need to provide the conditions that encourage new ideas and pedagogies to emerge and to either train or find leaders of educational technologies who have the knowledge and skills to accomplish more than the maintenance of the status quo. Marc Prensky (2008) in his article “The role of technology in teaching and in the classroom” offers one example of how 21<sup>st</sup> century learning is different from what has been practiced in the past. As Prensky stated the “role of technology in our classrooms is to support the new teaching paradigms” and then elaborates on these paradigms stating,

Although it can be stated in many ways, the basic direction is away from the “old” pedagogy of teachers “telling” (or talking, or lecturing, or being the “Sage on the Stage”) to the “new” pedagogy of kids teaching themselves with teacher’s guidance (a combination of “student-centered learning,” “problem-based learning,” “case-based learning,” and the teacher’s being the “Guide on the Side.”)... technology’s

role – and its only role – should be to support students teaching themselves (with, of course, their teachers' guidance.) (p. 1)

In order to begin to realize new, 21<sup>st</sup> century ways of teaching and learning it is imperative that the three themes in this chapter are addressed by educational leaders.

These are: (1) “keeping up” in a time of perpetual change in educational technology; (2) ensuring the provision of enabling infrastructures and (3) leadership is critical in addressing these themes.

## Chapter 6 – Conclusion

### Synopsis

Given the increasing use of information and communication technologies (ICT) in education and the corresponding increase in financial challenges to support and maintain ICT in schools and school districts, I became interested in exploring ICT options that are cost-effective and provide reliable, sustainable and relevant technological systems for teachers and students. I wondered if the free/libre open source software (FLOSS) I was utilizing in my computer lab with my students could be used school or district-wide to alleviate some of the financial pressure constantly upgrading proprietary software put on my school's limited funding and, if it was feasible, how could it be implemented and supported. I was also frustrated with the lack of technological support, the unsustainable nature of the technology I was using and the inability of my students to access school-based software and resources from outside of the school. Therefore, my specific purpose with this study was to research the how and why aspects of one school district's, district-led and district-wide open source software initiatives.

To answer my research questions, I invited personnel working in one exemplary school district to take part in this research. It is a district in British Columbia, Canada that started implementing open source software on thin client machines in 2008, and is now nearing completion of their district-wide implementation. In addition to informal discussions, observing a "staff session" with a school staff about to experience the transition to open source software and observing students and their teacher in a school computer lab already utilizing open source software, I personally interviewed the school district's Director of Information Technology, the districts Technology Coordinator, an

elementary school vice principal, a school technician and an elementary school teacher in order to obtain detailed answers to and descriptions of my research questions. A third form of data collection was reviewing documentation on the district-led implementation. These were publically available websites and blogs, the district's technology plans, and media articles.

### **Research questions.**

My research questions focused on how and why a district initiated and implemented a district-wide technological change. This interested me because the district I was working in, and others in my region, were using a dated Windows environments on ageing machines. My hard-working tech was not able to keep up with the failing systems and there was no plan, at either the district or school level to improve or update this unsatisfactory teaching and learning environment. Therefore, I wanted to know if this other district had found a solution to the problems I was experiencing and, if they had, how the district transitioned the computers and how both the transition and the new technology were viewed by staff. To this end, my main research questions were:

1. Why and how did the district choose to implement these changes?
2. How did the school district implement these changes?
3. How do educational stakeholders in these districts view these changes and do the changes affect teaching and learning?

### **Findings**

*I'm thinking why would you want to put in old computers that somebody has cast off already for the basis of your technology? I mean, I know they're cheap, but they're cheap because they're old. (Chris)*

This inquiry was guided by a complexivist paradigm or world view, based on the contention that societal and educational systems are complex systems nested within, connected to, supported by and influenced by other complex systems. Therefore, in addition to the characteristics of the changes themselves, when I studied the changes in the technological systems in my case, I studied them within the context of the school district and the society the district was within. For instance, as technology in society is constantly evolving to meet the needs of users, schools and school districts must also plan to evolve and adapt their technological systems in order to co-evolve with the technological changes in society. Also, based on the complexivist paradigm, the software and hardware systems utilized must not only have the capacity to co-evolve and adapt to user needs, but must be philosophically congruent with those of education at this time.

**Why and how the district chose to implement these changes.**

Based solely on a job interview presentation by their current Director of Information Technology, the secretary/treasurer, superintendent, and assistant secretary/treasurer made the decision to hire Chris, allocated the required funding and approved the transition of the technology in their entire district to the model Chris proposed during this interview. Chris's interview presentation was informed by his 15 years of experience as the manager of technology at another BC school district. While in this position he transitioned that district to open source software running on thin client machines. I see this "pretty bold move on their part", as Chris described it, as a move by the school board to bring reliable and affordable technology to a district that had failing, unsustainable and unaffordable technological systems throughout its schools.

I found this new direction to be intriguing because unlike the district I was working in which had no technology plan in place, no published future direction of technology and from a computer teacher's perspective the director of technology seemed to only "manage the status quo", this district had a published plan of improvement, a plan for the future and a director of technology actively involved in making improvements. And also unlike my district, which has no obvious plan to co-evolve with society or provide current software and hardware for students, my research site had a plan in place to co-evolve with society in order to meet the current and future needs of staff and students.

Although I am looking at the situation with hindsight, I don't agree with Chris's view that the school board's decision was a bold move. They explored their space of possibilities by interviewing candidates and chose to move away from managing the status quo by hiring a director with a known background and history of success in the implementation of thin client machines running FLOSS. As expertise of this magnitude is rare – there are now only two out of sixty school districts in British Columbia utilizing this technology and realizing the cost-savings, reliability and adaptability - I see the district as being fortunate and the decision of the school board as forward-thinking and wise. – This seems like a pretty bold move to me!

#### **How the school district implemented these changes.**

The school board set aside two million dollars from their reserved capital budgets to fund the district-wide one-for-one replacement of almost every computer in the district from desktop machines running proprietary Windows or Macintosh software to thin client machines running FLOSS. The changes were made over a four year period. The first year they trialed software and hardware at one new elementary school and then made

changes to their technology plan based on the positive and negative feedback from this first implementation. In the following years the elementary, middle and secondary schools and then the board office were transitioned to the new hardware and software.

Each school was transitioned individually. First of all this was accomplished by sending Randy, the district's technology co-ordinator, to the school to discuss the upcoming changes to the hardware and software. At these introductory sessions he explained to staff how they would access their current files on the new system as well as how to access email and the Internet. Randy described this to me as "just enough, just in time" training with a purposely limited objective of ensuring staff could perform and access basic computer functions and files in the few days following the transition. Second, this pre-training was followed by a team of technicians arriving at the school to remove the old hardware and install the new. In the following days Randy and this team were also available to provide further one-on-one and just-in-time training for the teachers and staff members in that school while both of these groups became more familiar and comfortable with the new technology and then advanced to more complex and specific training for those teachers who requested it. The transition time took between one week for a small elementary school and one month for a high school. One aspect of this implementation that I found unique was the high level of support offered to school staffs. Not only was the team of technicians available, but the district's technology co-ordinator did not merely oversee the transition from the school board office, he set up his office in each of the schools for a period of time extending from before the school was transitioned until well after. This enabled him to both oversee the transition and to be immediately available to assist the school staff members with any hardware and software

questions or concerns that arose. In my experience, this hands-on approach and technician availability is unique in a school district as, in my experience there is often no in-person support offered when technological or other changes are made. In fact, at my school when the technology was upgraded or changed a team would come in to the school, close the computer lab to staff and students, make the changes and then leave the school. Requests for technological assistance following these changes needed to be made via an Internet-based ticket system and, if time permitted, were filled by our school tech during his one half-day a week at the school. Needless to say, through no fault of our technician, the support was neither “just enough” nor “just in time.” Therefore, I see this hands-on, timely and fully supported approach to technological change as an enabling and a new and positive approach to making changes and supporting school staff through these changes. I think this bountiful support contributed to the positive view on the transition that all my interviewees described.

**How educational stakeholders in the district view these changes.**

The teachers, administrator and technician that I interviewed viewed both the change process and the new technology itself as positive and one that meets their needs. The copious support and assistance that was provided during the transition was looked upon very favourably and the move from technology that was often unreliable to the new reliable technology was also viewed as a very positive change for both teachers and students. I was surprised that there were so few complaints about changing email programs or document software (i.e. from Word to LibreOffice Writer) to the FLOSS equivalents. In my experience, even when Word has been upgraded, school staff members complain about the changes and some always need assistance adapting. I

suspect the difference is due to the amount of support given. One concern voiced was in regards to movie making software as at the time of the transition there wasn't any FLOSS that duplicated iMovie. As the open source community is very responsive to the needs of society, I think this will soon change, if it hasn't already. The only other complaint I heard was that some formatting in Microsoft Word did not correctly convert to LibreOffice Writer. For instance, because the fonts are slightly different, tables and worksheets made in Word may not appear exactly the same when opened in LibreOffice Writer. This issue was especially prevalent when the school board office was still using Microsoft Word and the schools had moved to LibreOffice. There are "work-arounds" for this, such as saving documents as a .pdf, however as a .pdf file can't be easily edited, this solution is not perfect. Despite these nuisances, the overall view on the changes was generally seen as positive.

### **Do the changes affect teaching and learning?**

The new district hardware and software changed how, how often and how reliable access to information and software was for students and teachers. The reliable technology and classroom data projectors have facilitated and encouraged access to Internet-based resources to support the curriculum and having ubiquitous access to all school software and district-based social networking tools have increased students' access to educational resources both in and out of school. Also, district-hosted school and teacher webpages and social media tools have facilitated home-school communications, collaboration and 24/7 access to these school resources and software. Despite these advancements, I did not see, nor did any of my interviewees discuss any changes to either curriculum or the overall way in which teaching and learning occurs.

After I had seen the tools that were available to teachers in the district, I had several of my own ideas for how I would have used the tools to support a social constructivist approach, such as on-line collaborative projects. Greenhow, Robelia and Hughes (2009) support this viewpoint. They stated, “Increased cloud computing software, run over the Internet rather than locally on a user’s computer, will likely intensify the participatory and creative practices discussed” (p. 255). I did not see as much collaboration as I expected to. However, now that the reliable technology is in place and the district is looking to teachers to help utilize the technology in innovative ways, the technology has the *potential* to facilitate a change in teaching and learning. This is one aspect of the change that I would like to re-visit in a few years after Chris has put in place his plan to look to teachers for guidance on how to use the new technology to support education and his plan to support teacher-led technology initiatives and professional development. I would hope to see technology-supported innovative 21<sup>st</sup> century teaching and learning that has been able to evolve and spread in a district that supports and facilitates the conditions that encourage complexity. It is these changes in teaching and learning that are crucial in determining if the technological changes I have witnessed and studied have been merely successful or a key element in the transformation of educational practices in this district.

### **Contribution to Knowledge**

The original contribution to knowledge found in my thesis is the detailed and pragmatic description of how one school district successfully transformed their failing technological systems to one that is viewed as reliable and sustainable by the teachers and other staff members in their district. Furthermore, by identifying the enabling structures,

utilized by the district it is possible to determine how this particular district provided the conditions to support this complex system while it underwent a successful transformation. Although several authors (Davis and Sumara, 2010; Mitleton-Kelly, 2003 & Reigeluth, 2008) have acknowledged that managerial behaviors can provide the conditions to enable complexity, these behaviors have not been researched in the context of a school district with failing technological systems. Davis and Sumara (2010) acknowledged the pragmatic aspects of complexity research and how current research is focusing on occasioning complexity. They stated:

Since 2000 or so, complexity research has become decidedly more pragmatic in its emphases. Elaborating its ongoing interests in description and analysis, a strongly articulated component of the current work is on occasioning the emergence of complex phenomena – that is, not just identifying them, not just better understanding what makes them go, but more deliberate efforts to trigger them into being, to support their development, and to sustain their existence. (p. 31)

Reigeluth (2008) also discussed understanding complexity as a means to improving the transformation process:

An understanding of ...complexity is crucial to systemic transformation of our educational systems to better meet the rapidly changing needs of our children and communities....complexity can help us to understand and improve the transformation process as a complex system that educational systems use to transform themselves....to help our educational systems to correct the dangerous evolutionary imbalance that currently exists. (p. 36)

Therefore, the purpose of my detailed descriptions of this district is to describe one successful example of a transformation. With this research, I have intentionally provided in-depth real-life examples of the characteristics of this complex organization, whereas oftentimes in the literature although the characteristics are described, and pontificated upon, the reader is not provided with concrete examples and descriptions.

Another contribution to knowledge this research brings is a real-world example of the successful utilization of FLOSS in education. Despite the many researchers encouraging the use of FLOSS in educational settings, I was not able to locate any research on how to actually accomplish the impressive feat of transitioning a school or district to open source software. I was also not able to locate any research on the added benefits this model provided to students and teachers such as the ability to collaborate, to access software from outside of the school or experience social networking tools in a safe secure environment. Therefore the contribution to knowledge that this aspect of my research has provided is an extension on previous research that stated the advantages to utilizing FLOSS in education, without any pragmatic information on how this might be accomplished, because I have provided detailed descriptions on the processes this district took and the learning that ensued while transitioning an entire school district from proprietary to FLOSS as well as detailed information on the additional advantages (not previously mentioned in research) to the utilization of thin client machines running FLOSS.

As described in my research, open source software and thin client machines, if implemented by managers who have created the conditions that support complexity within their district, is one viable option for providing reliable, cost-effective and

sustainable technology that both meets the needs of students and teachers and can be adapted to continue to meet their needs in an ever-changing technological environment. The original intent of this research was to explore an alternative to the ageing technology currently utilized by many school districts. To this end, these findings are significant because they did provide one example of a possibility to ameliorate a problem that is facing so many districts both in Canada and around the globe. That is, how to address the issue of limited funding coupled with ageing and failing technological systems in a time when the government and society are putting a greater emphasis on technology use in education. Additionally, these findings give one successful example of how managerial behaviors contributed to a successful transformation of a complex system. It is my intent that the readers of my work will take away a better understanding of the characteristics of a complex system and an understanding of FLOSS as well as an element of inspiration to occasion complexity in their own educational environment.

### **Implications and Recommendations**

Given managerial will, the conditions that encourage complexity in an educational setting, can be provided by district leaders. This is not to say that certain managerial behaviours will guarantee this outcome for, as Davis and Sumara explained,

Complexity cannot be scripted or managed into existence. However, it can sometimes be occasioned....such occasioning is contingent not only on the appropriate conditions being in place, but for attentions to be oriented toward the appropriate level(s) of complex activity. Or, phrased somewhat differently, an education that is understood in complexity terms cannot be

conceived in terms of preparation for the future. Rather it must be construed in terms of participation in the creation of possible futures. (p.43)

Therefore, whether sweeping changes are being made to one area of a curriculum or a general attitudinal change is the goal, district leadership can occasion, by focusing on the conditions to encourage emergence, complexity in a school district. This practice may require a financial commitment on the part of the district, however the resulting transformation and ability to continue to transform in order to co-evolve with society, thus meeting the needs of teachers and students, would be a positive outcome of these efforts and financial commitment.

As schools and society continue to evolve, education and the technology used to support education must also evolve. Decision makers in schools, districts and governments need to be cognizant of the effects their technology decisions will have on students, educators and families. Due to the tremendous cost to school districts of purchasing and maintaining high functioning technology and the effectiveness of managing these functions centrally, it is one of the few school-related initiatives best managed centrally and in the manner as lights and water - in a top-down fashion. Due to this management style is it imperative that managers of technology have a clear understanding of the needs of their district, a plan for meeting those needs and the ability to receive feedback and evolve in order to meet the changing needs of students and teachers. Before district leaders chose a product for schools the message that product sends and its ability to co-evolve with society must be carefully evaluated as this research has shown the negative impact the utilization of second-hand computers and proprietary software can have on our students and families. This sentiment of ensuring that the

technology chosen by school leaders meets the needs of society is not new. The technology may be recent, but the advice was also give over 100 years ago by John Dewey:

Whenever we have in mind the discussion of a new movement in education, it is especially necessary to take the broader or social view. Otherwise, changes in the school institution and tradition will be looked at as the arbitrary inventions of particular teachers; at the worst transitory fads, and at the best merely improvements in certain details — and this is the plane upon which it is too customary to consider school changes. ..The modification going on in the method and curriculum of education is as much a product of the changed social situation, and as much an effort to meet the needs of the new society that is forming, as are changes in modes of industry and commerce. (Dewey, 1900, p. 20)

Additionally, and to avoid the fads and arbitrary inventions described by Dewey, any changes to the technology that supports education must be implemented with complexivist behaviours and goals at the forefront of planning and implementation to ensure a positive outcome and further co-evolution.

Free/Libre Open Source Software (FLOSS) is a better choice for education than proprietary software. Not only does it, as I previously described, have moral, ethical and financial advantages over proprietary software, but FLOSS is, in itself, a self-organized complex system that can change and adapt to meet the needs of teachers and students. Also, it is a complex system nested within a complex educational system, which when combined has the potential to become greater than the sum of its parts. It is these values

that form the basis for my rationale for stating that FLOSS is the better choice for education.

### **Transferability**

This study took place over the course of three months in a relatively small school district - 8,000 students in eight elementary schools, three middle schools, and three secondary schools. The students primarily came from middle income, single-family homes.

At the onset, this research was designed to be a time-limited single case study of one exemplary district in western Canada utilizing an alternative form of technology as the basis for their district's technology. To this end, I was able to locate and research exactly the environment I had envisioned. If the research had included other school districts, or if I had studied the district over a longer period of time, it is possible that I may have been able to increase the transferability of my findings by recording a wider variety of observations. Also, the opinions expressed by my participants may have shown more variation.

Although the sample size of my participants was not as high as I had originally anticipated, I did have a representative from each of the employee groups in the district. More representatives may have enhanced the findings of this study, but they also may not have had any impact whatsoever as I found little variation between the interviewees I did have. Triangulation was used to corroborate this by, "comparing the information obtained from multiple sources" (Springer, 2010, p. 394). These sources are the documents, multiple interviews and observations.

The original intent of this research was to investigate the pragmatic, historical and sociological perspectives of a district-led open source implementation in one exemplary district. I was able to meet the originally anticipated intent. Furthermore, I believe that the inclusion of my background information and experiences in technology education and the highly detailed descriptions also add to the believability of these findings.

### **Suggestions for Future Research**

My strongest recommendation for future research is to re-visit this district in two or three years because the director of information technology in the district described for me how they planned to support teachers in the sharing of innovations with one another and how they would be looking to the teachers to make suggestions on how this now-reliable technology could be used to better meet their needs and the needs of their students. Therefore the purpose of the re-visit would be to determine if the technology utilized in my case has had any significant impact on teaching and learning and if the district has continued to adapt and change as a complex system must. I would be interested in researching whether this district's exploration of possibilities and the provision of enabling infrastructure continued after the implementation is finalized, and if so, what impact have these enabling infrastructures had on the teachers and students in the district. Additionally, I would recommend researching how these changes compare to other districts that did not undergo this transformation.

Another area of future research would be to investigate several different school districts implementing either open source software and thin client machines or a different district-led and district-wide technological transformation in order to put a sustainable reliable system in place. The purpose would be to determine if management behaviors

again played a critical role in supporting complexity in these school districts as well. If so, the characteristics exhibited by the different districts could be compared and contrasted in order to increase the generalizability of the findings.

Due to the constantly changing nature of technology and its increasing use in education, it is imperative that I and other researchers continue to explore ICT options that are cost effective to our school districts and our communities while maintaining high functioning, sustainable and adaptable technology for all students and teachers. FLOSS and thin client machines are a viable option for school districts, however more research needs to be done on providing the conditions that enable complexity when introducing these or other new technologies into a school district, and the effect these technological options have on teaching and learning.

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## Appendix

### Appendix A Recruitment Letter August 2011

#### **Letter of Recruitment: Principals, ICT Teachers and Technicians**

Do you have experience using computers with K-12 students? If so, please consider helping me with my research on open source software (and other low cost initiatives) in your school district.

I am an ICT and classroom teacher in a K-5 public school (Victoria, BC) and a graduate student at the University of Victoria. I am investigating educators' (and perhaps parents') views on low cost alternative technology initiatives such as: Open Source Software, Cloud Computing, and the Wiimote Whiteboard.

Participation in this study can be a face to face discussion at a time and place convenient for you, over the phone/Skype or via email. The interview will take under 45 minutes and will focus on your personal teaching experiences and views on the software and hardware initiative in your school district. All interviews will be confidential.

Please contact me if I can provide you with any further information or if you are interesting in participating in this study.

Thank you for helping me with my research!

Cathryn (Katy) Connelly  
Graduate Student, University of Victoria  
katy@uvic.ca

*This research is being conducted under the supervision of Dr. Kathy Sanford.  
You may contact my supervisor at 250-721-7806.*

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## Appendix B Informed Consent Form

### School District Low Cost Alternative Technology Initiatives: A Case Study

You are invited to participate in a study entitled, “School District Low Cost Alternative Technology Initiatives: A Case Study” that is being conducted by Cathryn (Katy) Connelly.

I am an ICT teacher in a K-5 public school and a graduate student in the department of Curriculum and Instruction at the University of Victoria. Please contact me if you have further questions by emailing [katy@uvic.ca](mailto:katy@uvic.ca)

As a graduate student, I am required to conduct research as part of the requirements for a degree in Educational Studies – Technology Education. It is being conducted under the supervision of Dr. Kathy Sanford. You may contact my supervisor at 250-721-7806.

### Purpose and Objectives

The purpose of this research project is to investigate school district driven low cost alternative technology (LCAT) initiatives in British Columbia. Data will be collected using interviews, observations and documents in order to produce highly detailed and descriptive case study research.

My research will focus on the “how” and “why” aspects of district LCAT initiatives. It will describe the rationale for the implementation of LCATs, the processes followed for their implementation and the views on these changes by educational stakeholders in these districts. The purpose is to further understand school district-driven LCAT initiatives in British Columbia. My research questions are:

1. Why and how did the school district choose to implement LCATs?
2. How did the school district implement these changes?
3. How do educational stakeholders in these districts view these changes and do these changes affect teaching and learning?

### Importance of this Research

Researching district-initiated implementation of LCATs in British Columbia will produce rich new information for researchers, government representatives and many levels of educational administrators. Pragmatically, the potential adoption of these technologies by school districts would have a widespread influence on the affordability of technology for students, schools, teachers, families and communities across Canada.

### Participants Selection

You are being asked to participate in this study because you may have valuable insight into one or all three of the research questions.

### What is Involved

If you agree to voluntarily participate in this research, your participation will include discussing your view on the three research questions as well as any other aspects of district low cost technology initiatives you feel are important. Participation is merely a brief (30-45 minute) conversation with the researcher at a time and location that is convenient. If possible, I would also like to observe you with your students in your school’s computer lab. In order to help me with my record keeping, I will audio tape our conversation so that I can later transcribe it.

### Inconvenience

Participation in this study may cause some inconvenience to you, including up to 45 minutes of your time.

**Risks**

There are no known or anticipated risks to you by participating in this research.

**Benefits**

This research will provide valuable information to inform district-level technological decision making in the area of low cost alternative technologies in education. This research could lead to the improvement in district-led technology initiatives based on a better understanding of the process undertaken by other districts and the view on these changes as expressed by educational stakeholders in those districts.

**Voluntary Participation**

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your data will not be used in this study and will be destroyed

**Anonymity**

In terms of protecting your anonymity no names will be used in any research papers.

**Confidentiality**

Your confidentiality and the confidentiality of the data will be protected by securing it on a password protected computer and in a locked filing cabinet. I anticipate being able to provide anonymity to technicians, teachers, other staff and parents. Information from the district technology leader and the district will be more difficult to provide anonymity to, as there is only one ICT leader per district and only one district in British Columbia using only open source software.

**Dissemination of Results**

It is anticipated that the results of this study will be shared in academic publications and presentations, and a graduate student dissertation. Findings may also be shared with educational leaders and used for informing district-level technology decision making. Examples from exemplary situations will be the focus of any dissemination.

**Disposal of Data**

Data from this study will be disposed of within 2 years. Paper copies will be burned or shredded and electronic copies will be erased.

**Contacts**

Individuals that may be contacted regarding this study include:

Cathryn (Katy) Connelly [katy@uvic.ca](mailto:katy@uvic.ca) and Dr. Kathy Sanford [ksanford@uvic.ca](mailto:ksanford@uvic.ca)

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or [ethics@uvic.ca](mailto:ethics@uvic.ca)).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

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*Name of Participant*

---

*Signature*

---

*Date*

***A copy of this consent will be left with you, and a copy will be taken by the researcher.***

## Appendix C

### Semi-Structured Interview Questions –Non-Teachers

#### Semi-Structured Interview Questions – Non-Teachers

(LCAT= Low Cost Alternative Technologies such as: open source software, thin clients, cloud computing, portable apps, Wiimote whiteboard)

1. **Background:**
  - a. Interviewee's Name – (To be kept confidential)
  - b. Education – Where did you go to university and what did you take?
  - c. Length of time with the district
  - d. Positions held within and outside the district
2. **District Background**
  - a. Is tech offered as a prep?
  - b. Is there an ICT teacher or technician in every school? How often are they at the schools?
  - c. How is technology funded? (PAC, district)
  - d. Are there any factors that make your district unique?
3. **Hardware and software used at your school and by your students**
  - a. Is there any proprietary software – if so, why?
  - b. What software is used? (word processing, presentations, photo editing etc.)
  - c. What hardware is used? (types of computers, whiteboards, projectors, doc cameras, keyboards, etc.)
  - d. Do you use cloud computing, portable apps or the Wiimote whiteboard?
4. **LCAT\* Background and why did the district choose to implement LCATs**
  - a. What was your position when the district started moving towards LCATs?
  - b. What do you know about the reasons for your district choosing to adopt LCATs?
    - i. How and by whom was the decision made?
  - c. Do you think these reasons for implementing LCATs are more or less applicable/valid now?
5. **How did the school districts implement the changes to LCATs?**
  - a. What process was followed for LCAT implementation? (All at once, in steps?)
  - b. Was support or training provided? If so, to whom and by whom? How long?
6. **How did educational stakeholders (teachers, principals, techs, parents, students) view these changes?**
  - a. What were your initial thoughts when you learned of this upcoming change? What are they now?
  - b. Did this change affect the way teachers teach? Or the ways they can teach?
  - c. Does this change affect the ways in which students use or access technology?
  - d. Has this change affected education or curriculum at all? (Yours/others/district wide)
7. **If you were with a school district just starting to consider implementing LCATs what advice would you give them? Any “lessons learned”?**
8. **Any other thoughts on LCATs in your district you would like to share?**

**Appendix D**  
**Comparison of FLOSS, Proprietary Software and Cloud Computing**

Use	FLOSS Free/Libre Open Source Software		Proprietary Software	Cloud Computing Word Processing
	Installed	Portable	Installed	Internet-based tools
<b>Word Processing</b>	Open Office Writer	Portable Open Office Writer	Microsoft Word	Google Docs document Buzzword
<b>Presentations</b>	Open Office Impress	Portable Open Office Impress	Microsoft PowerPoint	Google Docs Presentation Zoho Show - <a href="http://show.zoho.com">http://show.zoho.com</a> <a href="http://www.empressr.com/">http://www.empressr.com/</a>
<b>Spreadsheets</b>	Open Office Calc	Portable Open Office Impress	Microsoft Excel	Google Docs Spreadsheet EditGrid - <a href="http://www.editgrid.com/">http://www.editgrid.com/</a> Zoho Sheet - <a href="http://sheet.zoho.com/">sheet.zoho.com/</a>
<b>Photo Editing</b>	Gimp Paint.net	Portable Gimp	Adobe Photoshop	Picasa - <a href="http://picasaweb.google.com">http://picasaweb.google.com</a> Sumo Paint - <a href="http://www.sumopaint.com">http://www.sumopaint.com</a> Aviary.com <a href="http://www.picnik.com/">http://www.picnik.com/</a> <a href="http://www.splashup.com/">http://www.splashup.com/</a> <a href="http://www.pixlr.com/">http://www.pixlr.com/</a>
<b>Web Browser</b>	Firefox	Firefox Portable	Internet Explorer	n/a An installed browser is required.
<b>Mind Maps or Webs</b>	Cmap Freemind	Cmap Freemind	Kidspiration	<a href="http://www.Bubbl.us">www.Bubbl.us</a> <a href="http://www.Gliffy.com">www.Gliffy.com</a> <a href="http://www.Lovelycharts.com">www.Lovelycharts.com</a> <a href="http://www.mind42.com/">http://www.mind42.com/</a>
<b>Painting</b>	Tux Paint	Tux Paint	Kid Pix	<i>Google Drawing</i> <a href="http://Canvastic.net">Canvastic.net</a> . <a href="http://artpad.art.com">artpad.art.com</a> <a href="http://Bomomo.com">Bomomo.com</a> <a href="http://allmymagic">allmymagic</a> <a href="http://Brushter">Brushter</a> <a href="http://Queeky">Queeky</a>
<b>Interactive whiteboard</b>	ActiveInspire	ActiveInspire	Notebook	<a href="http://dabbleboard.com">http://dabbleboard.com</a> <a href="http://www.wixie.com/wixie">http://www.wixie.com/wixie</a> <a href="http://www.virtual-whiteboard.co.uk/home.asp">http://www.virtual-whiteboard.co.uk/home.asp</a>
<b>Sound Editing</b>	Audacity	Audacity	Sound Forge	<a href="http://Myna">Myna</a> Splicemusic.com
<b>Media player</b>	VLC	VLC	Windows Media Player	Youtube.com
<b>Zip and unzip utility</b>	7-Zip	7-Zip Portable	Win Zip	Zipmyfiles.net Nippyzip.com Webzipr.com Wobzip.org
<b>Video Editing</b>				<a href="http://www.onetruemedia.com/">http://www.onetruemedia.com/</a>