A Conceptual Model

for Optimal Integration of Information and

Communications Technology in the Classroom

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Abstract

Teachers in many schools struggle to integrate Information and Communications Technology (ICT) as part of their teaching practice. Among the issues faced by teachers when attempting to integrate ICT into their classrooms are gaps in ICT knowledge and skills, lack of training and inadequate support and scaffolding. Other issues include inability to translate training into teaching practice and curriculum design and lack of access to current hardware and software. Research in the field addresses the exponential pace of technology development and obsolescence as well as the financial and educational implications of teaching and learning in such an environment.

Teachers are core to the integration of ICT in the classroom and hence are often under pressure, since ICT integration is not just about having the right hardware and software; it is deeper and covers many layers. Integrating ICT requires a harmonious synchronicity of content, teacher knowledge, compatible theoretical framework and suitable pedagogy all at the appropriate stage of knowledge acquisition.

To help teachers better integrate ICT in classrooms with limited technology, a model was developed using literature in the field. The dynamic three-dimensional model presented here addresses some of the issues raised by teachers and researchers when integrating ICT. The model focuses on five areas of content, teacher knowledge, theoretical perspective, teacher role in the learning process and pedagogical approach and also examines three phases encountered in the process of learning with technology. The

model was designed to help support teacher ICT integration in K-12 schools. However the model could be used as-is or adapted for use in rural communities and developing countries where ICT is scarce and the student-computer ratio is much higher.

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CHAPTER 1

INTRODUCTION

Since the advent of the personal computer and the beginning of the Information Age in the 1970's, there has been a continuous effort to introduce new technologies into teaching and learning in education. The approval of Information and Communication Technology (ICT) integration universally in the education system has frequently been touted on the assumption that technological implementation and changes will improve and transform the system and provide students with a stronger position to deal with working in the information age. Pelgrum (2001) suggested that ICT is considered to go beyond providing the infrastructure for the Information Society to serving as a medium for reform that converts students to 'productive knowledge workers' (p.163).

Scholarly research in this area confirms the belief that the implementation of ICT in science and mathematics education can help improve students' problem solving skills, theoretical understanding, and group productivity skills (Culp, Honey & Mandinach, 2005; Tao & Gunstone, 1999). Eggen and Kauchak (2003) observed the advantages to students on an internal level and suggested that technology can elucidate motivation in learners by compounding self-efficacy and self-esteem, increasing attendance, fostering goodwill towards educational institutions, eagerness towards activities outside classrooms and more student participation in learning activities (p.420).

On an external level, the benefits to students were noted by the International Confederation of Principals (ICP) (2003) as the ability to transcend time and space in transforming learning both inside and outside the classroom (p.1). Among additional perceived benefits to learners that the principals noted were quick access to enormous amounts of information, global access to quality material, opportunities to interact with peers and experts without any geographical restrictions. Also noted were the possibility of experimenting with simulations and working with a variety of tools appropriate for diverse learning styles.

Similarly, Dhanarajan (2002) summarized benefits for learners suggesting that an enhanced and personalized learning milieu that caters to the desired pace, peers and place of learning can be brought about using the tools of ICT like email, internet, audio-visual media, and computing (p.74). These tools and opportunities were previously unavailable to educators until the 1990's.

However, it should be noted that ICT does not cater to all the educational needs. In fact, if used incorrectly, it could create problems and add to those previously present (ICP, 2003). In order to integrate ICT in the classroom environment, a number of factors need to be aligned for a successful ICT setup. These include, appropriate hardware and software, computers proportional to the number of students, teacher understanding and commitment to the technology as well as ICT appropriate teaching methods and techniques (Becta, 2004; UNESCO, 2004). The complexity increases when there are blurred lines between what each school means when they refer to ICT integration (Hadjerrouit, 2009).

> Hadjerrouit (2009) referred to Rautopuro (Rautopuro et al., 2006; Webb, 2002), in suggesting three facets ICT in school education:
>
> a) The use of ICT to support teaching and learning processes, using word processors, spreadsheets or databases in disciplines like mathematics or science.
>
> b) The provision of educational materials like LMS (Learning Management System) or Web-based learning to create a learning environment in order to facilitate learning through ICT.
>
> c) To learn the processes, concepts, skills, and knowledge of ICT as a discipline in itself (p.155).

Schools (K-12) are under pressure to implement all the three aspects of learning ICT, however with limited support, this goal is not always possible and mostly ICT integration is a balancing act by implementing some of each of the three aspects. Frequently in schools, there is a mismatch between the availability of finances to purchase the technology and the price of current technologies available in the market. This problem is amplified because "digital technologies morph and change quickly at a rate that generally outpaces curriculum development" (Johnson et.al., 2011, p.4). With limited budgets and dwindling government support (http://www.cbc.ca/news/canada/nova-scotia/story/2012/02/10/ns-school-boards-funding.html; http://www.thestar.com/news/gta/education/article/1210468--toronto-and-peel-school-boards-prepare-for-biggestcuts-since-harris-years), a number of schools set their ICT policies and type and level of integration based on what they can afford. This situation puts tremendous pressure on teachers who are expected to flawlessly integrate ICT in their classrooms under such conditions.

To further confound the issue, teachers vary in their background and approach to ICT. Research in this area shows that in a significant number of schools, the potential of learning with ICT is lost as several educators still have gaps in their ICT knowledge and hence do not use ICT in their teaching despite its apparent benefits for educational purposes (Bingimlas 2009; Pelgrum 2001; UNESCO 2004). Another problem is that teachers are very seldom consulted when ICT policies are developed and their subsequent integration recommended. When this oversight happens, teachers are unable to develop a positive attitude towards ICT and hence reject the applicability of ICT in their teaching practice (Watson 1998; Woodrow 1992).

The National Teacher Survey (2005) of teachers based in the United States showed that only about 54% teachers integrate computers into daily instruction and just about 25 % believed that their training was adequate enough to use recent instructional software packages. Another noteworthy point was that just 21% of teachers thought that they had had adequate professional development training in the use of assessment software.

Ertmer (1999) suggested that teachers' classically entrenched core beliefs are resistant to change and therefore impact fundamental change. The analogous reality is that educational change is reliant on "what teachers do and think – it's as simple and as complex as that" (Fullan, 2007, p.129). The point being that the role of the teacher influences educational technology. Teachers' perception of and response to technology, and also their use of educational technology to achieve their intended outcomes will affect its future employment within the classroom (Roblyer, 2003 in Magliaro & Ezeife, 2007). McGehee and Griffith (2004) recommend that educators need to incorporate new technologies into their teaching so that they can maximize the potential benefits of ICT, resulting in improved student performance.

One of the elements impacted by the reduced financing capability of the school is student-computer ratios. A higher student-computer ratio in the classroom has been noted as a barrier to successful ICT integration (Pelgrum, 2001; Statistics Canada, 2005; U.S. National Teachers Survey, 2005; Korte & Hüsing, 2007; Bingimlas, 2009). However, all is not lost here, since studies have shown that increasing the number of computers showed no significant relationship to student performance (Hu, 2007; Lei, 2010). So the issue then boils down to 'optimal' usage of the technology on hand.

If group instruction and group learning using ICT is the current reality, then why not embrace it and modify current teaching and learning practices accordingly? Shared use of computers has been the reality since microcomputers were introduced into classrooms. Developmental and learning theories suggest that social interaction and peer support can stimulate learning and help in knowledge building. In the normal course of life, we gain knowledge through peer interaction and based on evidence, "under the right circumstances, groups are remarkably intelligent, and are often smarter than the smartest people in them" (Surowiecki, 2004, p.xiii). Hence, to support optimal learning using ICT, if we use a carefully planned approach instead of simply placing students together in groups, we should be able to achieve a successful learning environment that could potentially be richer than an individualized learning environment.

Keeping the benefits, obstacles and research-based realities of integrating ICT in mind, my research looks at ways in which educators can address some of the issues and support the integration of ICT in classrooms that have limited ICT infrastructure.

Statement of Purpose

The purpose of this study was to develop a conceptual model for integrating ICT in the classroom. To support the model design, current obstacles to ICT integration in the classroom were explored as were the issues faced by educators related to these obstacles. My research interest arises from a simple thought: if for over a span of 40 years there has been an effort to integrate ICT in the classroom, then why are we even now struggling to make this happen aptly? Research in the areas of technology and obsolescence, classroom student-computer ratios and teacher perspectives on the integration of ICT was gathered and analysed along with different learning theories and their applicability to ICT integration. The intent of this study was to use this current research to develop a conceptual model to support teachers in limited ICT environments in their integration of ICT in the classroom.

Research Questions

1) What is the current status of ICT in K-12 schools?
2) What impact does innovation and development in ICT have on the integration of ICT in the school?
3) What external factors contribute as barriers to the integration of ICT in the classroom environment?
4) What is the current status of ICT integration by teachers in their practice?
5) What issues hinder teachers from integrating ICT in their practice?
6) How does group instruction impact learning with ICT?
7) How might educators develop group instruction to optimize student learning?
8) What can developmental and learning theories contribute to the integration of ICT in teaching and learning?

CHAPTER 2

LITERATURE REVIEW

This literature review examines the impact of technology on ICT integration in K-12 schools as well as research in the area of school and teacher issues and attitudes towards the integration of computer technology in teaching practice. Also reviewed is relevant literature in the area of student learning, addressing various learning theories and research in group processes using ICT.

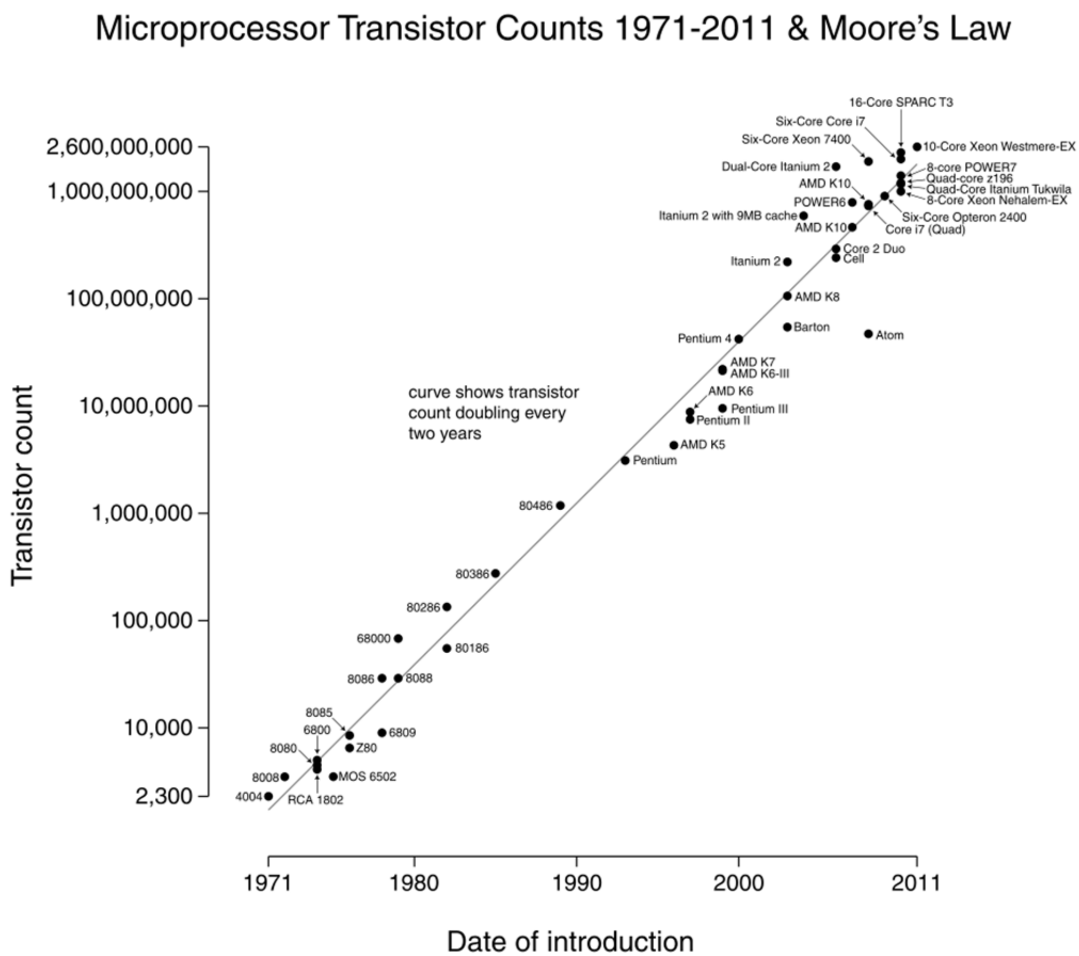
Technology and Obsolescence

"The only big companies that succeed will be those that obsolete their own products before someone else does" Bill Gates - Founder, Microsoft Corp.

The computer industry frequently and unfailingly launches products that are smaller, more powerful and less expensive than their predecessors. This stems from the conviction that every piece of technology so far, (hardware and software) is affected by Moore's law which states that "The number of transistors incorporated in a chip will approximately double every 24 months" (Intel, 2005).

Moore's law predicts and is valid to the way technology is advancing (Figure 1). However, does that mean that we 'need' the latest (better and smaller) technology in education to teach the basic concepts of other (non-computing) fields like Biology, History and so on?

Figure 1: Graphical Representation of Moore's Law



Source: Wikipedia

There are other factors at play and not just the fact that technology is moving at a rapid pace. Among these factors is the concept of ‘planned obsolescence’. Planned obsolescence is a term that can be traced back to 1932 with Bernard London's pamphlet ‘*Ending the Depression through Planned Obsolescence’* in which right at the beginning (even before a product is manufactured) the idea is to deliberately make sure that the product’s useful life is limited. This causes the consumer to feel the need to purchase newer products as replacements for the older ‘obsolete’ ones.

In the technology industry, Sandborn (2007) suggested that hardware and software have developed a symbiotic relationship where hardware enhancements trigger software manufactures to make their software obsolete in relation to the hardware technology. This situation in turn causes older hardware to become out-dated. For example - CorelDraw X5 needs a minimum processing power of Intel® Pentium 4, AMD Athlon 64 or AMD Opteron. But a Intel® Core™ Duo 1.83 GHz, AMD Dual-Core 2.0 GHz or higher is required for video editing (Corel Corporation).

Hindle (2008) conceptualized this software/hardware relationship using the analogy of children being born with the ability to speak a language that they understood but their parents could not, yet being able to understand the language of their parents. Similarly, new versions of software can understand and communicate with previous generations of the software but communication in the opposite direction may not always be possible, thus reducing the utility of older versions in time (p.147).

As an example of hardware requirement changes necessary for running the newer software, see Table 1. In the older version of Windows Operating System (OS), Windows 98, the minimum memory requirements were 64MB, which now have increased to 1GB (1024MB) for the Windows 7 version.

Similarly highlighting the case of changes in newer and improved software, for example, let us examine the differences in the Microsoft program – Word (a type of document typing and editing software). As seen in Figure 2, between the product's first launch in 1989 and the following 10 years, the number of toolbars went from 2 to 23 (Figure 3), to 31 in another 4 more years (Figure 4) and more in the following years (Figure 5)! So by the time people are trained to understand the workings of the new software, the newer one is launched or ready to launch, starting the whole process of training again.

Aronson (2008) confirmed that by the time many of us get our hands on the latest piece of technology, there is already the successor (or replacement) getting ready to roll out of the manufacturing plant. Hence, the major concern with adopting new technology in schools is that it puts an incessant strain on the limited budgets and dwindling resources often leaving a significant number of schools with either obsolete technology or high computer to student ratios for new technology. With technology advancing and rapidly getting obsolete, for schools, there is an emergent widening gap between the integration of advanced technology and teaching and learning. For teachers, it becomes a challenge to integrate this ongoing advancement into the classroom, which in turn impacts the student.

Table 1: Summary of Increased Hardware Requirements with Each OS Launch

Operating System	Minimum Memory	Minimum Disk Space
Windows 98	64 MB	500 MB
Windows Millennium ME	96 MB	2 GB
Windows 2000 Professional	96MB	2 GB
Windows XP Home	128 MB	2 GB
Windows Vista	512 MB	15 GB
Windows 7	1024 MB (1 GB)	16 – 20 GB

Figure 2: Screen Capture of Word for Windows 1.0 (Launched 1989)

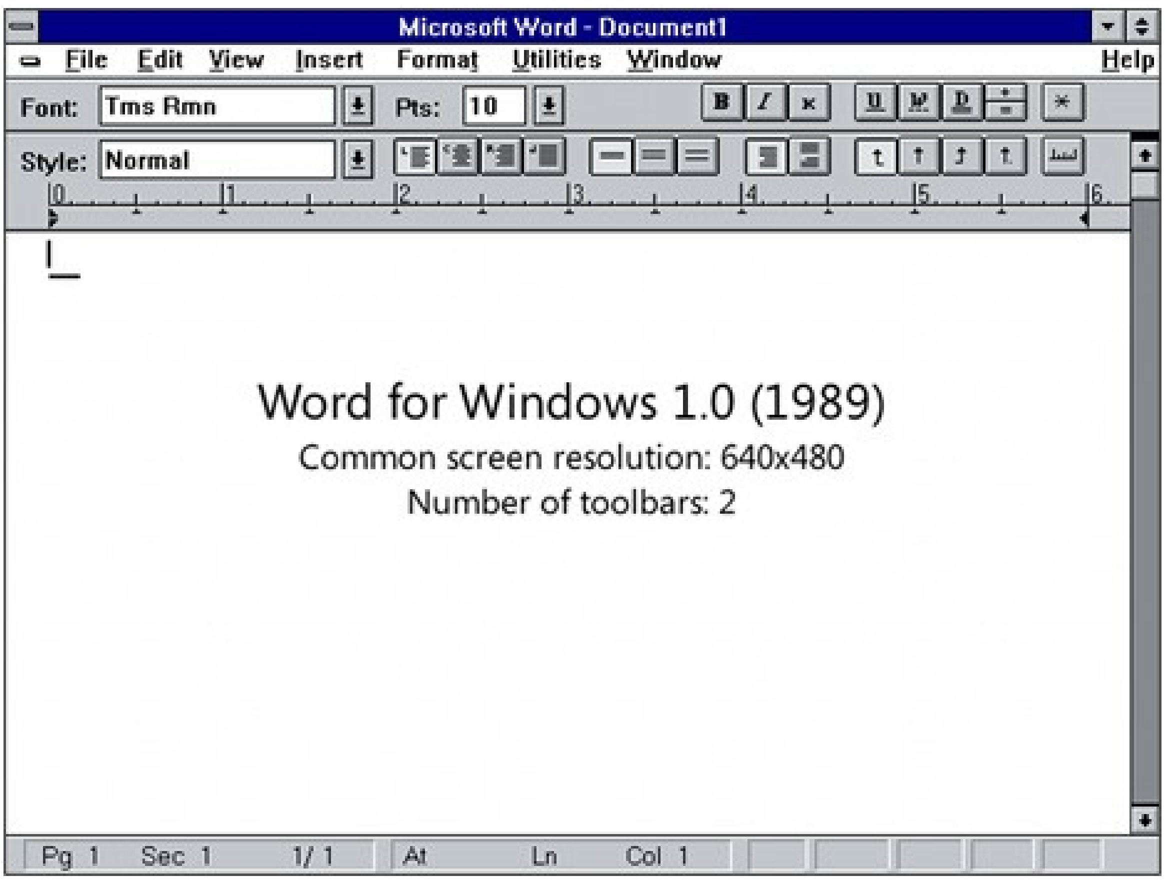


Figure 3: Screen Capture of Microsoft Word 2000 (Launched 1999)

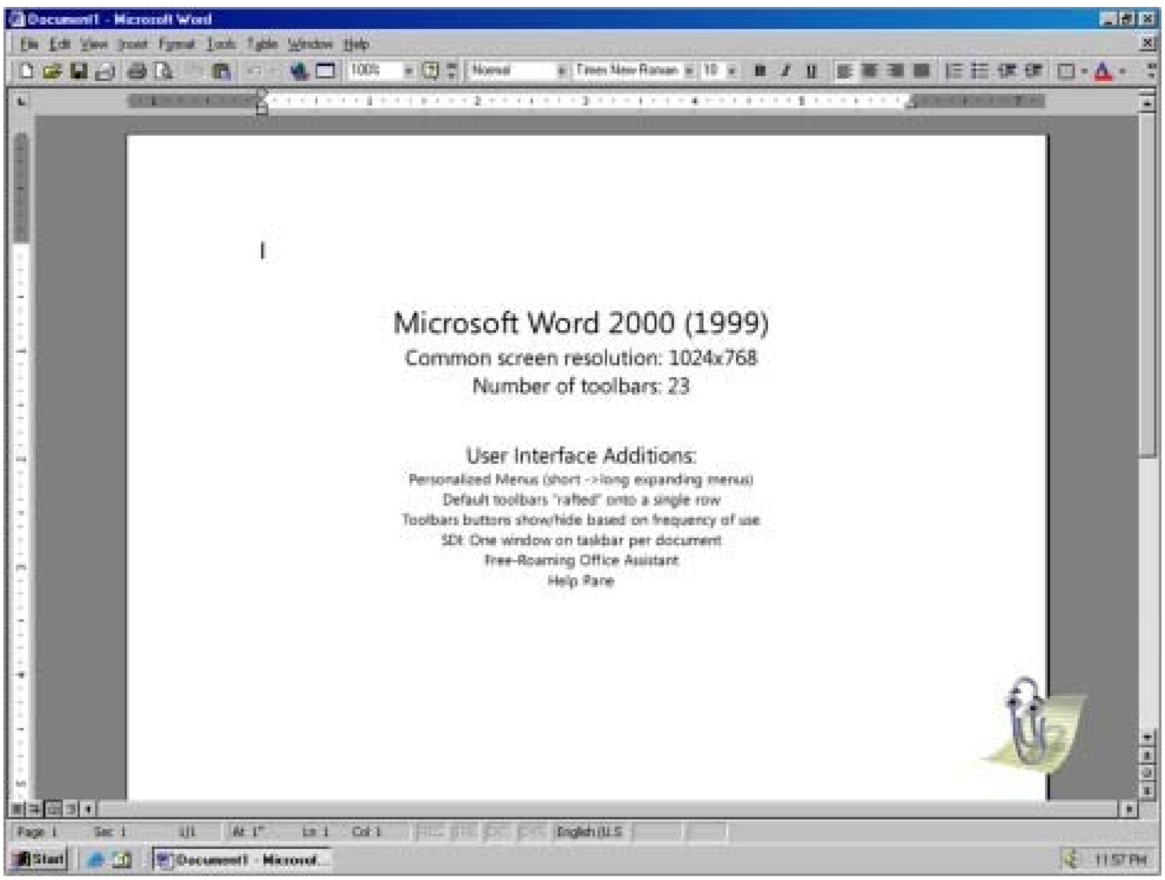


Figure 4: Screen Capture of Microsoft Word 2003 (Launched 2003)

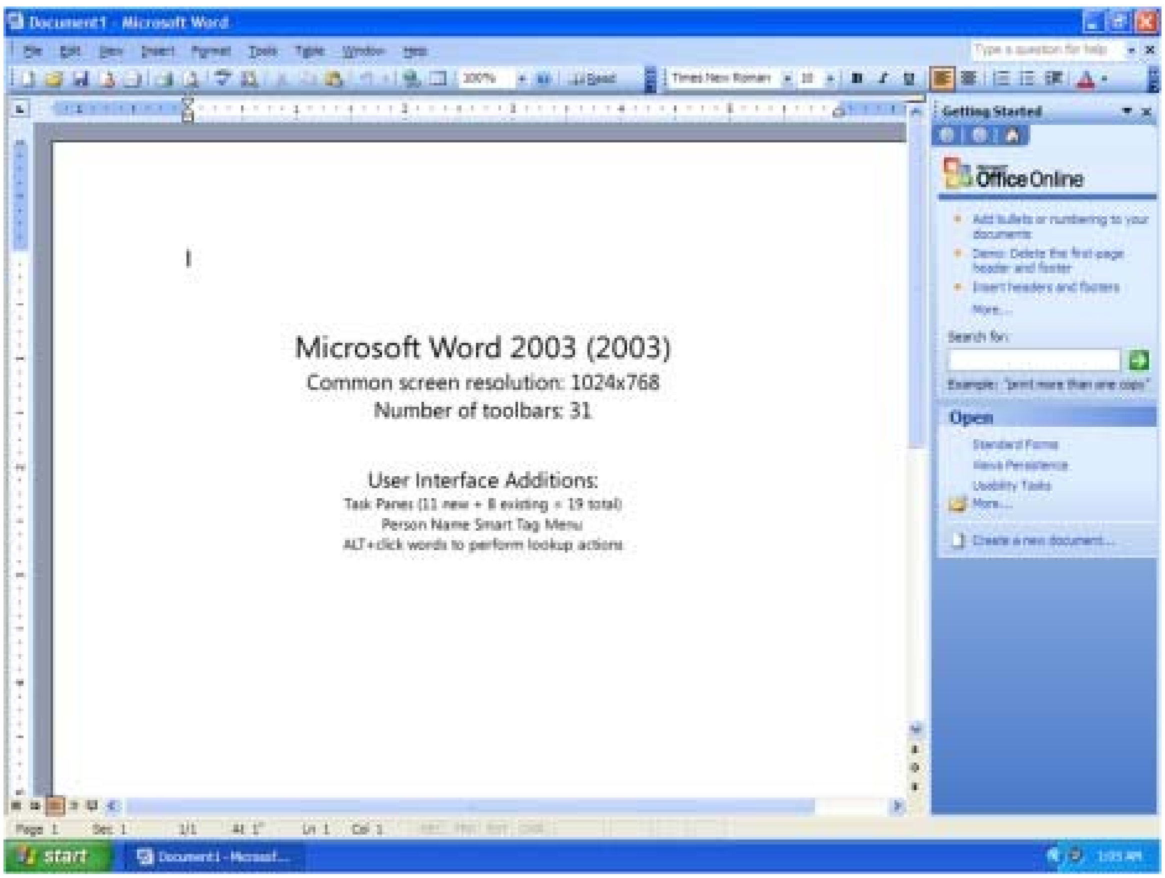
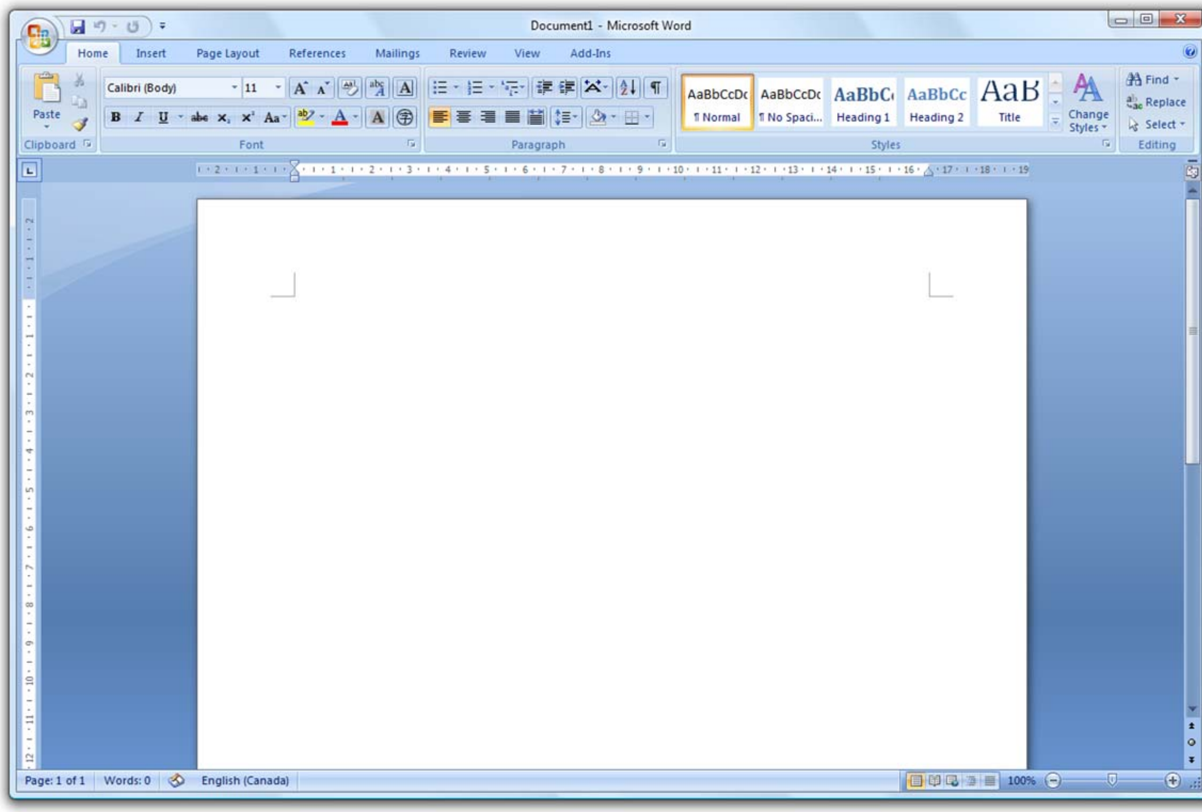


Figure 5: Screen Capture of Microsoft Word 2007 (Launched 2007)



Current Setup in Schools

According to the Merriam-Webster dictionary, a Personal Computer (PC) is defined as: “A general-purpose computer equipped with a microprocessor and designed to run especially commercial software (as a word processor or Internet browser) for an individual user”. The key terms I wish to highlight here are ‘personal’ and ‘individual’. Both terms confirm the fact that the PC is a single user machine and has not been designed for the use of more than one user. However, this has not been the case since the introduction of microcomputers in schools, and even today many schools allocate a single PC to multiple users.

Schools are under pressure to allocate significant time and money for integrating technology into curriculum, with the prime intent of improving student academic achievement (OECD, 2001; Plante & Beattie, 2004; U.S. Department of Education, 2000). Since teachers are fundamental to any integration plan, they have been under pressure to learn technology skills and then teach by incorporating ICT into their practice. However, current trends of increasing budgetary constraints and projected economic conditions make it difficult for a large number of educational establishments to provide this technology adequately to their students (Ali, 2007; Zhao et al., 2002).

Validating the costs associated with technology acquisition, in a significant number of schools, it is unlikely that the PC is used ‘individually’. According to Plante and Ertl’s (2004) report, published by Statistics Canada, in 2003/04 about 72 computers per school were used for educational purposes. With a median of 12 minutes per school computer dedicated to support and maintenance each month, the number of working PC's for use available at one time for teaching drops below the average of 72 computers per school. Also, less than 25% of the K-12 schools in Canada were operating with around 50% of their PCs running the most recent Operating System (OS), with Quebec and the Atlantic provinces trailing the list (Statistics Canada, 2004).

Research surveying educational practitioners, over a number of countries spread across continents, identified that an insufficient number of computers hindered the integration of computing technology in schools (Bingimlas, 2009; O'Mahony, 2003; Pelgrum & Law, 2003). Similarly, Mumtaz (2000) reported similar results and further suggested that both an insufficient number of computers and improper software can significantly impact the implementation of ICT. Under these conditions, options for appropriate technology use are reduced, hindering the opportunities available to the quality use of ICT in the classroom.

Can it be assumed that if a sufficient number of computers are made available with appropriate software, then we should be able to integrate ICT in schools easily? Fabry and Higgs (1997) noted that the appropriate amount and right types of technology along with adequate access is vital for the effective integration of computers and that a suitable numbers of computers alone does not assure proper utility of the technology.

Table 2: ICT technical support time by province and territory

ICT technical support time by province and territory, 2003/04	
	Minutes per computer per month
	(median)
Canada	**12**
Newfoundland and Labrador	12
Prince Edward Island	6
Nova Scotia	12
New Brunswick	18
Quebec	18
Ontario	12
Manitoba	12
Saskatchewan	18
Alberta	12
British Columbia	12*
Yukon	6*
Northwest Territories	18*
Nunavut	X
* Lower reliability estimates due to sample size. x Suppressed to meet confidentiality requirements of the *Statistics Act*.	

Source: Statistics Canada (Table 5, 2003/04)

This issue is echoed by Zhao et.al. (2002) who state that; "Although in recent years there is a great progress in bringing computers and networks to schools, we found that in many schools teachers did not have easy access to either of the two infrastructures" (p. 512). Based on observations of the above mentioned researchers, it can be said that if teachers have poor access to technology, it will be reflected in their integration of ICT and teaching. Norris, Sullivan and Poirot (2003) point out the importance of accessibility for teacher's use as: "…teachers' use of technology for curricular purposes is almost exclusively a function of their access to that technology" (p. 25).

Although we can contend that access is key, once the technology is available in the school, however, researchers have identified more facets of the issue and highlight a number of other equally vital factors that weigh in similarly with regards to the integration of ICT in schools. According to Becta (2004), improper organisation of resources, low quality hardware, inappropriate software, or lack of access each can impact the ICT usage in schools. The report *'Integrating ICTs into education'* by UNESCO (2004) cites that "The integration of computers and technology into schools is an expensive and sometimes complex process. It requires all the necessary equipment, competent staff to get it up and running, technical support, and teaching of others to use it correctly and effectively"(p.7).

Table 3: Access to computers by school characteristic

Access to computers by school characteristic, 2003/04							
	All schools	Elementary	Secondary	Urban	Rural	Public	Private
All schools							
Average number of computers	**72**	53	134	80	49	74	50
Average number of students	**351**	294	608	406	197	370	198
Median student-to-computer ratio	**5.0**	5.5	4.3	5.4	3.8	4.9	4.7
Small size							
Average number of computers	**32**	31	46	34	30	35	23
Average number of students	**106**	112	137	118	92	114	77
Median student-to-computer ratio	**3.4**	3.7	3.1	3.7	3.1	3.4	3.9
Medium size							
Average number of computers	**65**	53	117	68	56	66	59
Average number of students	**301**	273	490	322	235	306	258
Median student-to-computer ratio	**5.0**	5.5	4.6	5.3	4.3	5.0	5.6
Large size							
Average number of computers	**112**	74	227	114	102	111	132
Average number of students	**629**	487	1,145	645	502	630	588
Median student-to-computer ratio	**6.3**	6.9	5.1	6.4	5.3	6.3	5.8

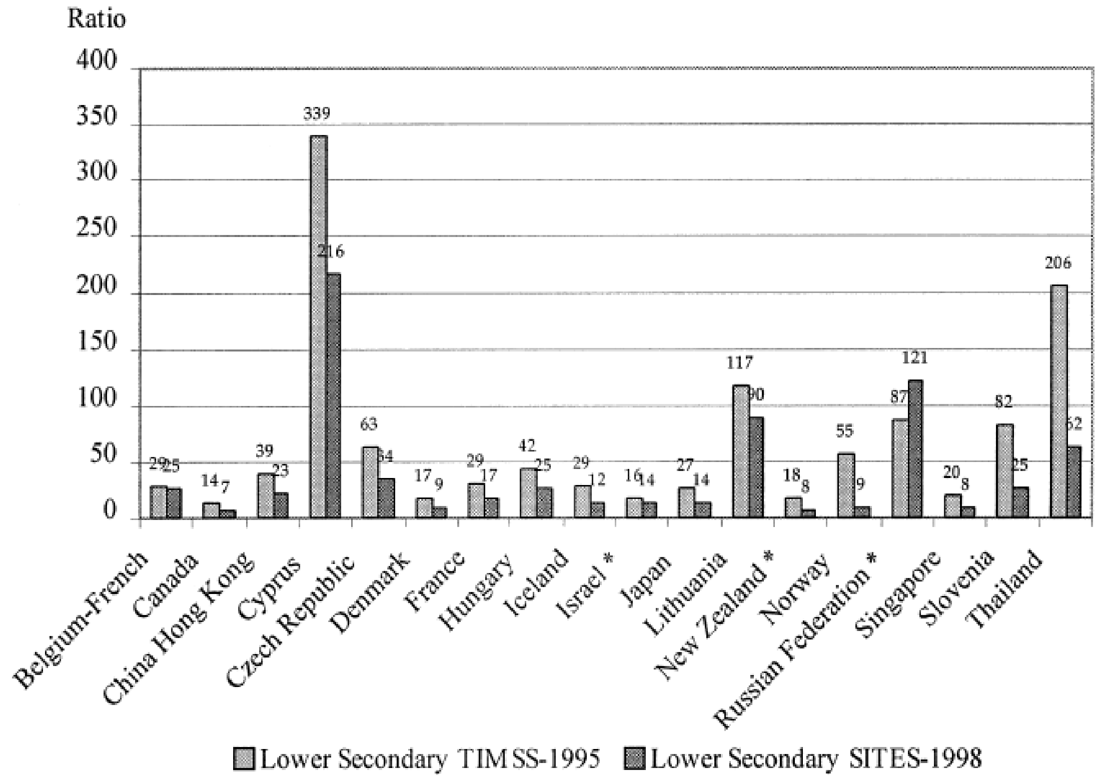
Source: Statistics Canada (Table 6: Access to computers by school characteristic, 2003/04)

In Nova Scotia, the ‘Computers for Schools’ program operates where people and businesses can donate their used but still useable computer equipment to the program. The point to note here is that most of the equipment is older and has been used. Assuming that planned obsolescence is a factor, the equipment should be reaching a point where it has ‘lived its life’ and hence the possibility of equipment failure or breakdown starts to increase. Bennett (2011) claimed that “Nova Scotia has 60,000 computers in a system serving 127,000 students, many of which badly need replacement” (online report). This claim is validated by the Nova Scotia Department of Education in their ICT report published in 2005 which states that “In Nova Scotia, 77 technicians support approximately 40,000 computers (a ratio of worse than 1:500)” (p.9). Findings by Preston, Cox, and Cox (2000) as well as the British Educational Suppliers Association-BESA (2002) suggested that when the equipment available is old and less reliable, teachers tend not to embrace using ICT in teaching.

Student Computer Ratios

In his survey on educational practitioners’ views in 26 countries (from the continents of North America, Oceania, Asia, Africa and Europe), Pelgrum (2001) identified that the top barrier to successful implementation of Information and Communication Technologies (ICT) in schools was an insufficient numbers of computers. An international comparison of student to computer ratios is depicted in Figure 6. This sentiment was echoed in the United States by the National Teachers Survey (2005) which found that 62% teachers responded to not having the right computers to student ratio in their classrooms.

Figure 6: Comparison of student/computer ratios - lower secondary schools (1995/98)



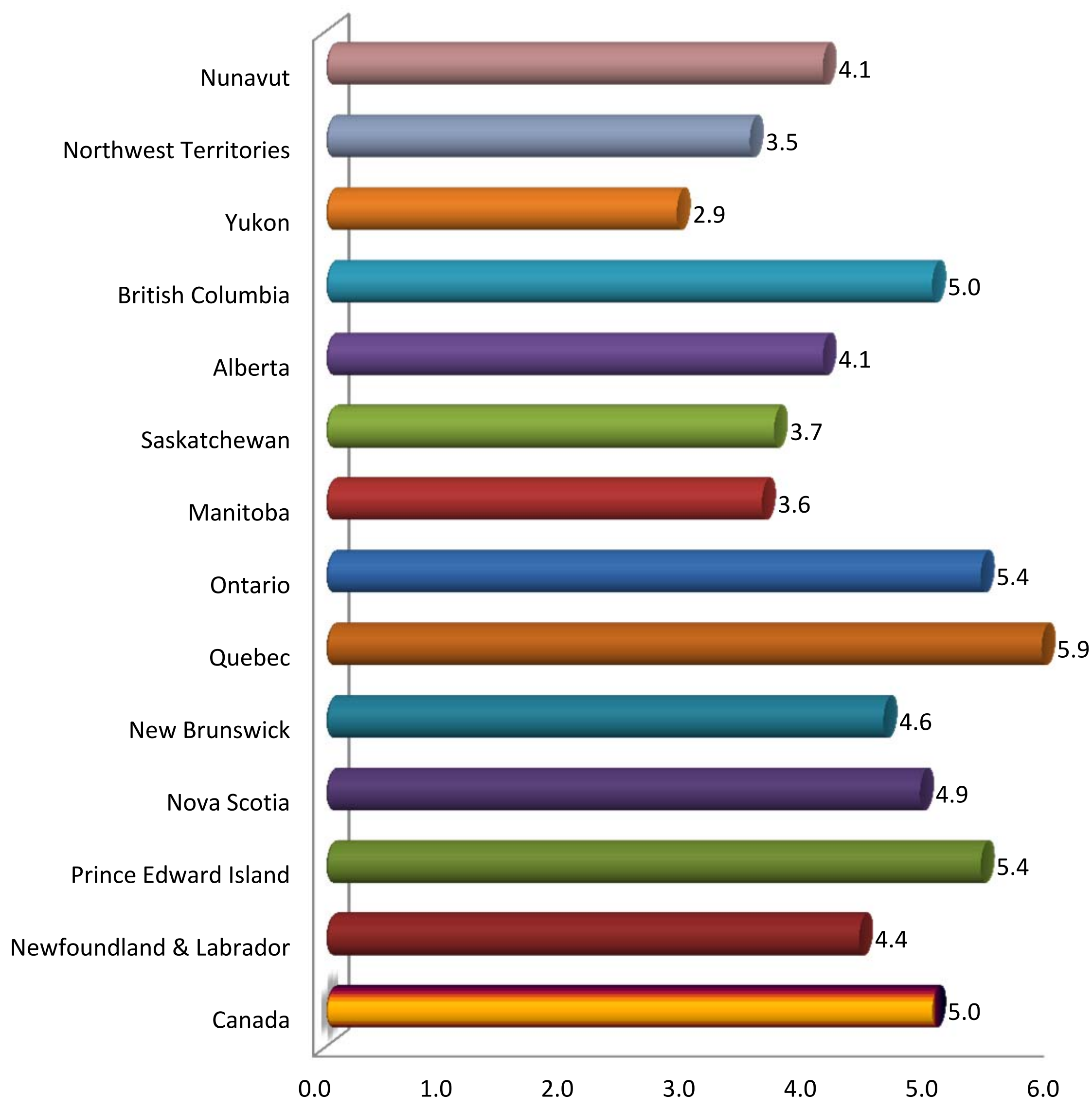
Notes: Estimates are for all schools, that is, including non-computer using schools. *: country did not satisfy all guidelines for sampling.

(Source: Pelgrum, 2001) (includes all schools: computer using as well as non-using).

According to research conducted by Korte and Hüsing (2007) covering 27 European countries, they observed that in schools in Europe, a computer is shared on an average by 9 students. In Canada, the school median is 5 students per computer (Statistics Canada, 2005) and is represented in Figure 7. This number still falls short of the current research suggestions by Corbett and Wilms (2002), that recommended that ratios better that one computer per four or five students, are necessary to ensure significant improvements in learning. However, for essential practices to be fundamentally changed, DiSessa (2000) suggested that the critical ratio is one computer per three students. According to the US National Teachers Survey (2005), only 13% of teachers had one computer to two or three students in their classroom.

Fabry and Higgs (1997) found that a large number of schools highlighting their low student to computer ratio had a significant number of computers that did not provide easy access for learning and were of poor hardware and software specification. This situation makes us question the value of such low ratios, since such dated technology and incompatible software specification would not be able provide the improvements suggested by Corbett and Wilms (2002) and Disessa (2000) in learning. More recently, Larkin (2011) questioned the optimal one computer per student ratio recommending instead that one computer be available for every two students. His research suggests that "1:2 computing is preferable to 1:1 computing to achieve a balance between productivity, student engagement, social activity, and individualised learning" (p.101).

Figure 7 : Student-to-computer ratio (median) by province and territory



Source: Statistics Canada (Chart 3: 2003/04)

Studies have shown that increasing the number of computers showed no significant relationship to student performance (Hu, 2007; Lei, 2010). However, Lei's (2010) study also suggested that "for technology to have meaningful impact on teaching and learning, close attention must be paid on the quality of technology use: how is it being used, what is used and for what purposes" (p.468).

Teacher integration of Computing Technology

McGehee and Griffith (2004) recommended that educators need to incorporate new technologies into their teaching so that they can maximize the potential benefits of ICT, resulting in improved student performance. The Algemeen Directeurenoverleg Educatieve Faculteiten (ADEF) (2009) suggested that a teacher should be proficient and competent in key areas in order to integrate ICT in the classroom.

These key areas were:

1. <u>Instrumental skills</u>

The teacher has enough technical or operational skills required for the use of a computer in order to employ ICT in lesson situations and in educational organisation.

2. <u>Information skills</u>

The teacher is knowledgeable about media and skilled regarding information.

3. <u>General pedagogics</u>

The teacher makes appropriate use of ICT in lessons and is able to combine digital and non-digital teaching materials (blended learning), to make learning more effective and/or efficient.

3.1. <u>Presenting</u>

The teacher is adept in integrating digital material into lessons and can employ varying pieces of hardware to achieve desired educational outcomes.

3.2. <u>Collaborating and communicating</u>

The teacher is familiar with a number of synchronous and asynchronous digital forms of communication and is able to employ these in the lessons.

3.3. <u>Working individually</u>

The teacher is able to guide students working independently with ICT.

3.4. <u>Guiding and evaluating</u>

The teacher is able to use ICT in teaching and evaluating students. To this end the teacher is capable of gaining insights into the student's learning using ICT.

3.5. <u>Testing</u>

The teacher is able to develop/compile, administer and evaluate simple digital tests.

4. <u>Designing and developing</u>

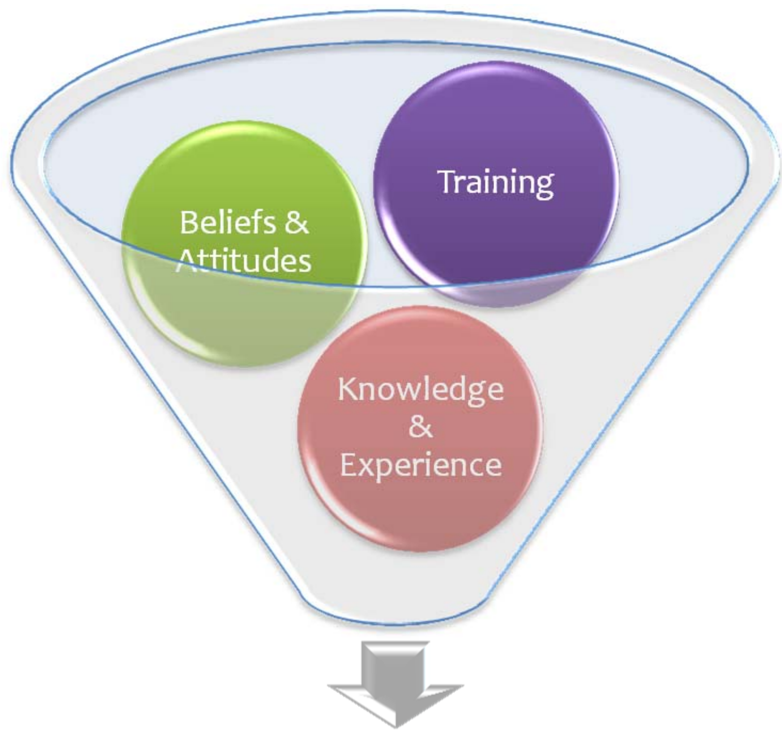
The teacher can use ICT for designing and /or developing digital teaching material. (p. 3-6)

However, research in this area showed that in a significant number of schools, the potential of learning with ICT was lost as several educators still have gaps in their ICT knowledge and hence do not use ICT in their teaching despite the apparent benefits of the use of ICT for educational purposes (Bingimlas 2009; Pelgrum 2001; UNESCO 2004).

The US National Teacher Survey (2005) showed that slightly over half (54%) of teachers integrate computers into daily instruction and just about a quarter of them thought that their training was adequate enough to use current instructional software packages. Professional development training in the use of assessment software was perceived as adequate by only 21% of teachers. These statistics suggest that a majority of teachers might resist adopting technology-related practices.

Research by Barak (2006) suggested that teachers are cautious about integrating advanced technologies in schools even though they take advantage of ICT for their personal development and learning. The reason that teachers are cautious can also stem from research like Slaouti & Barton (2007) who observed that hindrances such as time pressures, accessibility of equipment, lack of mentors and opportunities for apprenticeship or observation also have an impact on teachers' ability to integrate ICT. Globally, researchers believed that integrating ICT for instructional purposes eventually rests on the attitudes of teachers toward the technology (Huang & Liaw, 2005; Teo, 2008). In the case of learning environments, technology optimization should not be the 'holy grail'. For instance, although there are potential benefits of using ICT in teaching and learning, one should bear in mind that the value of knowledge that can be imparted and gained on its own with limited use of technology is valuable. This sentiment is echoed by the President's Panel on Educational Technology (1997) who suggested that lessons using ICT should "emphasise content and pedagogy, and not just hardware" (p.8). That is, the focus when implementing ICT might shift from student learning and achievement to the state and capability of the technology. Such a focus would need to be examined critically.

Figure 8: Teachers' Personal Barriers to Integration of ICT



Earlier research in this area of teacher integration of ICT in the classroom still shadows some of the current issues faced. Hodas (1993) talked about “technology refusal” by teachers, identifying concerns that teachers sometimes fear both technology and loss of control that might result from increasing technology use in the class. Tying these concerns in with current research by Tella et al. (2007), it was found that “inadequate knowledge to evaluate the role of ICT in teaching and learning, lack of skills in the use of ICT equipment and software had resulted in a lack of confidence in utilising ICT tools” (p.14). So since 1993, limited changes have occurred in regards to some of the factors identified as hindrances to the integration of ICT by teachers.

Some of the key factors like teacher attitude, experience, knowledge, training and integration of ICT into the curriculum are discussed in detail next. A visual depiction of these factors is presented in Figure 8. These factors can be either facilitators or hindrances. In Canada, according to Statistics Canada, the usage and acquisition of ICT by teachers is in line with research in other jurisdictions.

Table 4 presents the most recent data collected by Statistics Canada in the context of teacher ICT development. It shows the percentage of schools that promote teachers’ understanding of ICT and the techniques they use in helping them learn and integrate the technology in their practice.

Table 4: Strategies to Help Teachers Learn How to Use ICT

	Mentoring or coaching activities with teachers or ICT professionals	Information-sharing or discussion with staff	Personal learning activities	Professional development	Training sessions	Staff meetings	Organized after-school sessions
	% of schools						
Canada	**25.1**	**18.2**	**14.6**	**12.8**	**12.2**	**8.0**	**7.2**
Newfoundland and Labrador	17.3	12.7	6.6*	7.8	6.1*	4.4*	X
Prince Edward Island	27.4	17.4*	x	13.6*	x	x	X
Nova Scotia	21.0	16.1	16.4	11.9	10.2	5.5	5.5
New Brunswick	20.4	12.6	12.0	10.0	12.3	7.6	8.7
Quebec	30.9	16.8	20.6	11.7	19.3	10.2	9.8
Ontario	24.9	21.4	12.6	13.1	10.6	8.6	7.1
Manitoba	24.9	16.9	14.5	14.0	14.8	5.6	4.9
Saskatchewan	19.7	13.9	12.0	10.9	10.4	5.3	6.4
Alberta	31.3	21.8	17.3	20.2	13.0	9.0	8.8
British Columbia	17.8	12.8	11.2	8.5	7.0	5.7	4.0
Yukon	33.3	33.3	x	X	x	x	X
Northwest Territories	X	x	x	X	x	x	X
Nunavut	X	x	x	X	x	x	X

Note: Estimates reflect the answer category 'a lot of emphasis placed by principal on strategies to help teachers learn how to use ICT'.
* Lower reliability estimates due to sample size.
x Suppressed to meet confidentiality requirements of the *Statistics Act*.

(Source: Information and Communications Technologies in Schools Survey 2003/04, Centre for Education Statistics, Statistics Canada, p.26)

Beliefs and attitudes. Embracing and integrating ICT in the classroom can be strongly influenced by the teachers' attitudes towards ICT (Chai et. al., 2009; Drent & Meelissen, 2008; Jimoyiannis & Komis, 2007).

Kulik, Kulik and Bangert-Drowns (1985) conducted a meta-analysis of 32 comparative studies on the impact of computer-based instruction on elementary school students' achievement. This earlier research focussed on the student rank and achievement. Factors such as teacher's attitude and level of integration were given less weight at that time. These factors are now being highlighted in current research and acknowledged as having a significant impact on student learning.

Recent research into the barriers to ICT integration in schools highlights that teacher attitude is not just a personal dynamic, but it is strongly influenced by the support and scaffolding available to the teacher in terms of implementing ICT. This support and scaffolding also demonstrates itself in the form of access and failure rates of available equipment, the opportunities for training given and the school philosophy towards the integration and application of ICT in the environment. (Becta, 2004; Dawes, 2001; Ertmer, 2005; Mumtaz, 2000). For example, a teacher who is hindered by the failure of equipment on a number of occasions might reduce their integration of ICT in their teaching. When assessed, this situation can reflect as a negative attitude towards the integration of ICT. Awan (2012) echoed the research by Haydn and Barton (2006) by stating that "the reported attitude of teachers towards ICT tells us more about the equipment the teacher has access to, the training they have had, and the sort of teaching and learning community they are part of, than it does about the willingness of the teacher to use ICT" (p.258).

Teacher's attitudes in integrating ICT also have an impact on the attitude of the students towards ICT. Sime and Priestley (2005) in their research found that "individual teachers were also perceived as having the power to model children's attitudes towards ICT and their attitude in this sense was considered as crucial. When teachers were enthusiastic and dedicated to finding ways of using ICT in teaching, and gave pupils meaningful tasks on the computer, pupils were thought to be more involved in their learning with ICT" (p.137). Their research also found that "even when resources were limited and access to computer suites was problematic, students thought that the individual teachers' attitude was the vital factor in determining ICT use" (p.137).

Teacher's attitudes and beliefs are fundamental for the successful integration of ICT in education. However, they are not standalone factors in the integration of ICT. A positive attitude towards ICT along with the right support and scaffolding for the institution can go a long way in the successful application of ICT in schools.

Knowledge and experience. Pelgrum (2001) cited lack of skill and/or knowledge as well as issues with integrating ICT into the lesson, as the top non-material hindrances to developing a successful ICT school environment. These hindrances could be explained in the research completed by Oren, Mioduser, and Nachmias (2002) who noted that teachers had limited knowledge of integrating ICT into their practice since "… most current teachers' pre-service preparation, and subsequent in-service courses were devised in reference to traditional educational technology and settings (e.g., printed materials, frontal lectures, and face-to-face group work)” (p.15).

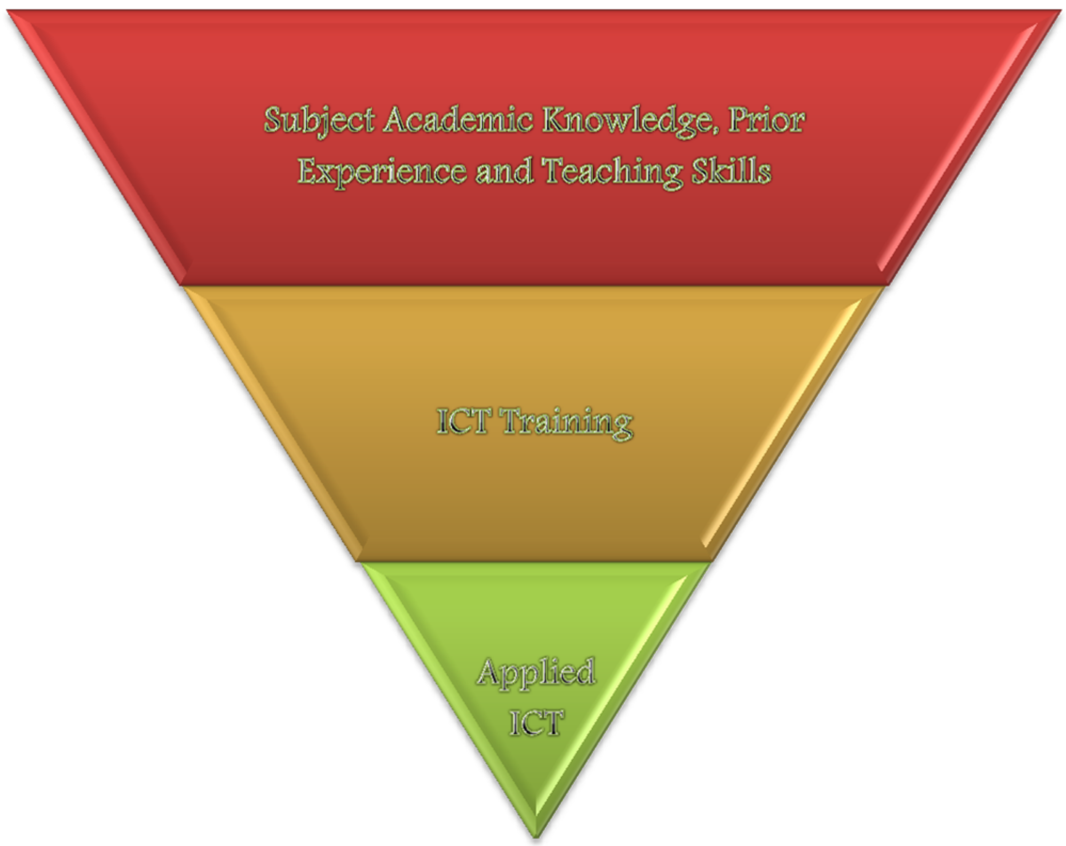
According to Oblinger and Oblinger (2005), most of the children born in and after the 1980’s belong to the ‘Net Generation’ (a term coined by Don Tapscott in 1997) where the use of technology and the internet were part of the environment growing up. Being exposed to ICT earlier on in their childhood makes technology an embedded part of the children’s thought process. This experience is in contrast to that of teachers who may not have had such an exposure and have to acquire this technology and the various aspects of the technology from the ground up.

The issue confounds itself when teachers who don’t have technical backgrounds have to integrate technology and achieve a level of proficiency in using the ICT. Montgomerie and Irvine (2001) noted that when schools employed graduates with a higher qualification in education, it was expected that they have a reasonable level of ICT knowledge and exposure to ICT implementation. Even in the case where the teacher may have had a formal training in Instructional technology, there is a very high chance that they have little to no knowledge on how to translate that training into their teaching practice and curriculum design (Bauer, 2000; Hardy, 2003). The problem here is that even though the teachers’ are entering the schools with a comprehensive grounding in their core subjects as well as training in ICT, there is a possible disconnect between their knowledge and successful integration of ICT with the subject matter and the subsequent presentation of that material for teaching.

The way this can be represented is in the form of an inverse pyramid (Figure 9). At the top, academic knowledge and prior experience along with teaching skills form the foundation of the pyramid. This foundation (in many of the current school systems) is enriched with ICT training (so that ICT can be integrated with the teaching). However, the final application and integration of ICT is heavily reduced and is not a cumulative effect of the merger of the two prior factors of foundational knowledge and ICT training (which ideally it should represent). In other words, ICT training that fails to focus specifically on integrating technology into classroom curriculum does not necessarily lead to the desired results. Since all thought processes occur inside the teachers' heads, they cannot be verified. However, how a teacher comprehends and then presents his/her knowledge to the class may be one of the most important variables in the implementation of ICT in the educational environment.

Borko and Putnam (1995) suggested that where knowledge directly influences a teacher's thinking, it predicts their actions in a classroom. To understand teaching, one must then examine the teacher's knowledge system, which includes the teacher's thoughts, judgements and decisions, associations between their knowledge systems and cognitions and how these lead to action. A famous quote attributed to Albert Einstein said, "Not everything that can be counted counts, and not everything that counts can be counted." To facilitate the improvement of teacher's practice, Borko and Putnam

Figure 9: Knowledge Pyramid



suggested that we assist them to expand their knowledge systems (p.37).

Training. Training teachers in the use (and eventual implementation) of ICT is vital for integrating ICT in the classroom. This area has come under scrutiny by the research community since there is an obvious relationship between training teachers in ICT and its subsequent implementation. The rational approach that most of the schools have taken since the introduction of ICT in schools is to train teachers in the use of ICT so that they can implement ICT in their respective teaching. This (expected) simple transition does not always translate from learning to teaching in a number of cases. The reasons are complex and multifaceted - from continuously upgrading hardware and software, to student computer ratios, to prior knowledge, to amounts of training and many more areas that are being highlighted as research in this area continues.

The type of training given is also noteworthy since according to Phelps, Hase and Ellis (2005), "many ICT programs are directive, training through a series of step-by-step instructions and concentrating on a particular program or computer utility" (p.68). The key issue here according to their research, is that computer technology is developing at a fast speed. For those individuals undertaking traditional learning in the use of a software program, the knowledge will become outdated rather quickly (p.68).

Browne and Ritchie (1991) found that a noteworthy constraint of in-service teacher training is that it becomes a medium for "simply providing knowledge to teachers and doing little to help transfer the skills to actual classroom implementation" (p.28).

Such transfer needs to be explicitly modeled – since it cannot be assumed that teachers will automatically generate these ideas on their own.

A significant number of teachers in training as well as in-service teachers accept the fact that they are not trained adequately and are frequently not given appropriate tools to implement ICT in their practice (Hardy, 2003). This finding corroborates that of the US National Teacher Survey (2005) when only one quarter of the teachers perceived that their training was adequate enough to support their use of current instructional software.

The issue spreads itself beyond the perimeter of adequate training. For example, Bosley and Moon (2003) found inconsistencies between the extent of ICT training received by a teacher and the degree to which the teacher applied that training in their practice. The authors believed, that this finding suggested a lack of confidence in relating the learning (from the training) into a successful implementation in the classroom. According to Brown and Ritchie (1991), the teacher must present the information in a cognitive form and also demonstrate confidence and autonomy in the application of the material with students during classroom utilization of technology skills (p.30).

Another dimension to consider is that training a person on the usage of a system does not directly translate to a full blown application of the product, since teachers are not usually given any specific training in the area of multiple users on single-user computer systems. In this area as well as others highlighted in current research, it has become crucial that teachers need to be specifically trained - not just in understanding how the technology works but also the applicability of the technology in order to successfully integrate ICT in their teaching (Markauskaite, 2007; Mitchem, Wells, & Wells, 2003; Yildirim, 2000).

Phelps, Hase and Ellis (2005) suggested that end-user computer education programs require modifications in attitudes, values and beliefs to allow change and provide the confidence for ongoing learning. They noted that program participants need application skills more than training because any directed learning software they learn in a training program will be outdated soon with its successor (p.68).

Group Instruction

When we interact with a computer system independently, we engage on a one-to-one basis. Based on our internal cognition, as well as interaction with the system, we adapt our knowledge. A simple structure developed to demonstrate the communication of an individual learner when using ICT is presented in Figure 10 where the user follows the process of interacting with the technology. Based on the task at hand, he/she deliberates on the response, and then inputs it into the system. Depending on the response, a feedback (or some visual or visual and auditory mixed) is generated by the system. This feedback is then analysed and then adapted into the knowledge of the individual.

However, with limited resources at hand and a variable ICT environment, group instruction is a reality (based on student-computer ratios and other inhibitory factors) in most classroom environments. The question then arises: How successful can we be in teaching ICT when we are working in groups?

Looking at the work of constructivist learning theorists like Lev Vygotsky and Jean Piaget provides us with a starting point. According to Vygotsky, learning takes place originally inter-subjectively (in small groups) and may then be internalized as intra-subjective (individual) learning. Piaget (1928/1995) suggested that “social life is a necessary condition for the development of logic” (p.120) and also in future work stated that “relations among individuals... modify the mental structure of individuals” (Piaget, 1950 as cited in DeVries 2000, p.190).

Schoenfeld (1989) in his work with college students highlighted the advantages of problem solving in small groups. He claimed that group work encouraged a healthy discussion and logical debate of issues and the opportunity to observe and appraise the group’s progress. He also claimed that this experience drew the group closer in their learning and strengthened their commitment to the intellectual values of the discipline.

Group learning does have its advantages in that, it involves active learning. When students get enthusiastically involved in the learning process, the result is usually a deeper understanding of the subject matter. In the normal course of life, we gain knowledge through peer interaction. According to Surowiecki (2004) research has shown that in certain situations, when a group is formed and knowledge is shared, the group as a whole is more knowledgeable than the individual knowledge of the smartest members of the

Figure 10: Individual Learner when Using ICT

group (p.xiii). Supporters of both Piaget and Vygotsky also agree on the importance of children's collaboration (Berk & Winsler, 1995; Whitmore & Goodman, 1995).

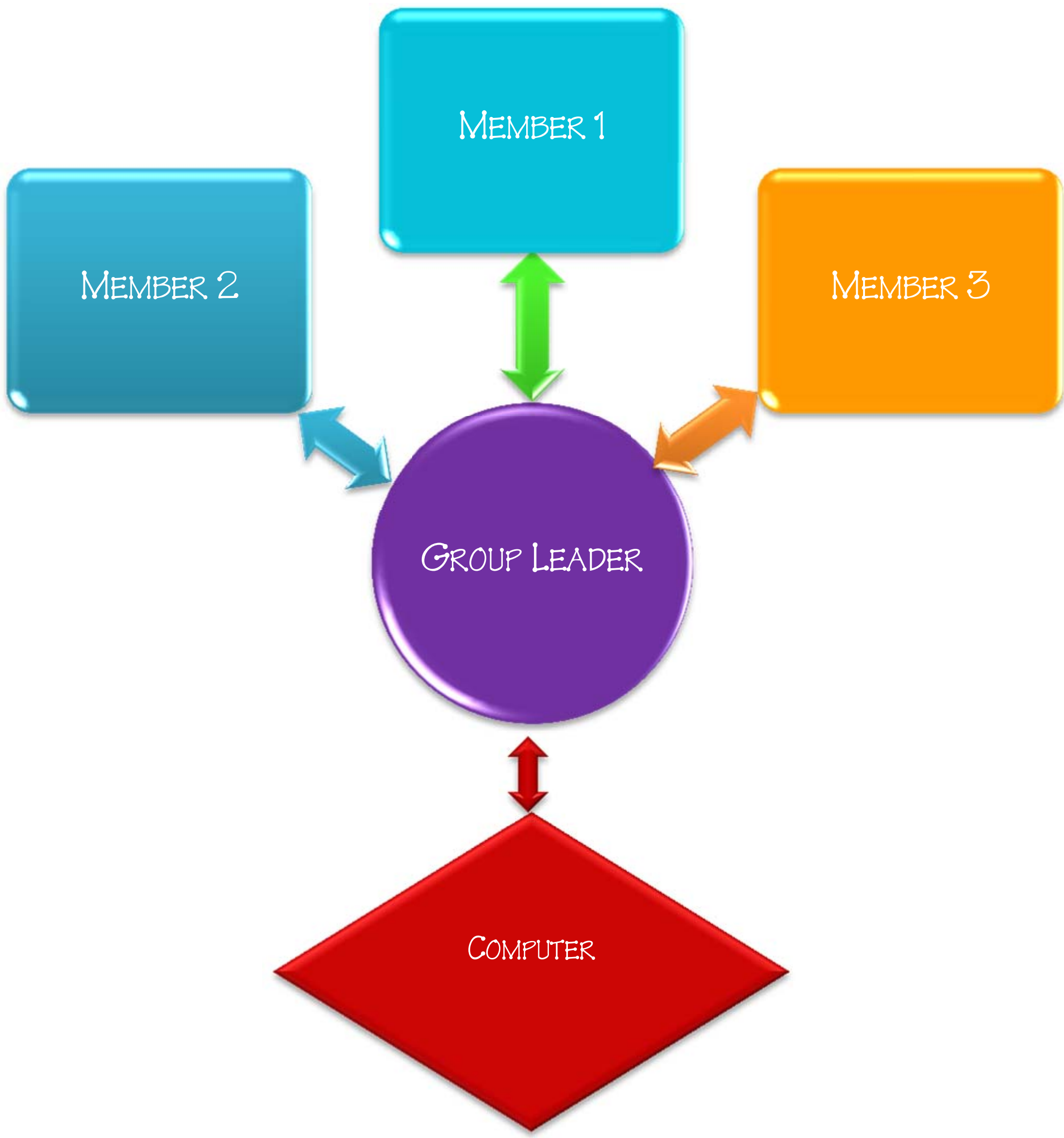
Stahl (2009) referred to recent studies stating that learning in small groups occurs differently than when students work independently (e.g., Barron, 2003; Cohen et al., 2002; Schwartz, 1995). Stahl claimed that group work showed significant difference when measuring individual learning through knowledge acquisition before and after an intervention. This finding suggested that differences are related to group processes such as the development of ideas or concepts.

However in an unstructured group format of ICT instruction, the average student's ICT learning might not be optimal. In such a situation, unstructured group work might not achieve the desired results, since in contemporary classrooms, diversity in cognitive processing, skill, knowledge and values is now the norm.

On the other hand there are issues that arise in groups. Some students may be reluctant to speak in small groups while others may not appreciate the need to engage in participation or be uneasy with the concept. These behaviours may stem from past experiences in education or the lack of confidence associated with not learning in their mother-tongue (Flinders University, n.d. p.1).

The traditional unstructured group format is represented in Figure 11. Here members are assigned to a group and given a task. In this commonly-used model which is

Figure 11:Unstructured ICT Learning Group Format



commonly used, the group appoints (or a member self-appoints her or himself as) the leader. This person then becomes the link between the group and the computer system.

The issue with such an arrangement is that:

- Since the 'leader' controls the interaction, he/she may eventually start taking control of the group's direction and dominate (Baines et.al., 2009)
- When the group decides a course of action; the 'leader' may take control and not allow others to share their knowledge.

Another key point that needs to be highlighted is that teachers can support their group instruction using the technique of cooperative learning or collaborative learning. The constructivist teaching method of cooperative learning can be highly beneficial in classroom learning. However, many teachers are unaware of the marked difference between group work and cooperative learning. Johnson and Johnson (1998) suggested that a cooperative group is a one with members committed to the common aim of maximizing each other's learning. By developing a cooperative learning environment, teachers can help students develop efficient learning techniques as well as effective social scaffolding of other group members. According to Dillenbourg (1999),

> … although collaborative learning may be similar to cooperative learning, the two types of learning differ. Cooperative learning has tasks divided vertically, which means that members work roughly simultaneously on different parts of a project, while in collaborative learning tasks are divided horizontally. Here members work together more sequentially on different parts of the project. (http://cel.curtin.edu.au/ePedagogy/student_ centred/collaborative.cfm, n.d.)

These methodologies of cooperative and collaborative learning are considered by Rockwood (1995) to demonstrate the differences between knowledge and power. In traditional cooperative learning, employed for foundational knowledge, the teacher was the locus of authority. In contrast, collaborative learning views knowledge as a social construct and sees the teacher abdicate authority in order to empower the group (http://www.wcer. wisc.edu/archive/cl1/cl/question/TQ13.htm, n.d.). It follows that group learning using ICT should be designed in such a way that educators can capitalize on the potential of the group process and simultaneously integrate ICT successfully within the group in order to maximize learning and knowledge acquisition.

Developmental and Learning Theories

Learning is acquiring new knowledge, behaviours, skills, values, preferences or understanding, and may involve synthesizing different types of information.

- Holt, 1983.

People have been trying to understand how learning occurs for centuries. Philosophers like Aristotle, Socrates and Plato debated on how to advance learning and what we could achieve by it. At the turn of the 20th century, various researchers approached learning from different perspectives. Burns (1995) defined "learning as a relatively permanent change in behaviour with behaviour including both observable activity and internal processes such as thinking, attitudes and emotions" (p.99). Burn's definition includes both behavioural and cognitive dimensions.

In order to grasp the implications of ICT on the mind, it is crucial for us to understand how people learn and develop their knowledge. Technology is changing rapidly and with that, the way we work with it is also changing. Initially a computer was developed as a tool to ‘compute’ complex mathematical problems but now technology has far more applications with many more new uses than was originally fathomed. The constant change in technology from the time of punch cards to today’s touch screens has an effect on the way individuals learn and that can sometimes go unnoticed.

The past half-century has seen a dramatic change in the way we view learning. How we learn has changed, as well as our understanding of it, largely owing to the introduction of technology in the classrooms as well as the meteoric rise of available software and a dense and diverse amount of information available on the internet. The ramifications of this change are still not fully understood, since the blueprint of teaching and learning that have been used for centuries are now struggling to survive and adapt in this new era of ICT where information is fluid and free-flowing to anybody who wishes to access it.

In order to completely understand the barriers teachers face in integrating ICT, we need to get a deeper understanding of student learning and how that can have an impact in the current school environments of varied levels of ICT application and integration. The matter of concern is that students do not properly understand how their utilization of technology affects their literacy or habits of learning (Barnes, Marateo & Ferris, 2007).

A learning theory is an attempt by researchers and philosophers to understand how people learn, helping us to appreciate the inherently complex process of learning. The main philosophical frameworks which cover the learning theories are: Behaviourism, Cognitivism and Constructivism (Kridel, 2010). Behaviourism in learning centres mainly on the external – what changes we can observe objectively. Cognitive theories on the other hand focus on explaining brain-based learning by looking beyond behaviour and inferring internal thought processes. In Constructivism, learning is viewed as a process wherein the learner actively builds/constructs new ideas and/or concepts. All three theories provide the basis for understanding for what occurs in the technological secondary classroom. These theories although broad in nature, have several consequences for the technological secondary classroom (Ebert, n.d.). Let us examine some of these learning theories and their relevance in today's ICT centric learning era.

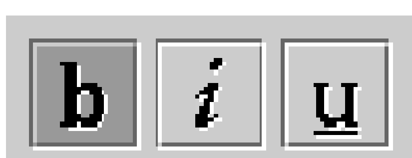
Behaviourist learning theories and ICT. Education has been influenced immensely by all aspects of behaviourist theory. For decades, Behaviourism was the foundation theory in the education realm. Behaviourism defines learning as the changes that take place in solely the observable behaviour of a learner in terms of stimulus-response processes. Behaviourists maintain a distance from cognitivists and constructivists through their disinterest in internal mental states of the learner. Instead, they focus their attention on what is observable behavioural change and therefore external.

Even in the field of educational technology, behaviorist reinforcement theory still maintains a wide impact. Many educational practices with implications for educational technology have been based on the idea of reinforcement from Skinner's statement that "behaviour is shown to be shaped and maintained by its 'reinforcing' consequences rather than elicited as conditioned or unconditioned response to stimuli" (Skinner, 1958, p.972).

Reinforcement was also seen in the feedback prompted through the use of drill and practice tutorials, with individual instructions as noted by Shield (2000). Shield suggested that teaching and learning strategies may need to be changed in accordance with varying learning objectives. Certain learning requires the presence of prior basic knowledge for more advanced information to be internalized and therefore the learning of factual information is often essential for the learner to be involved with more complex activities. Where competencies and standards are seen as indicators of achievement, behaviorism drives many a current educational practice (p.74).

I would like to elaborate a personal example of what has been mentioned here, I would like to elaborate. During a visit to a school in rural Rajasthan, India, I entered a classroom where the teacher was making the students memorize the tab buttons of the software program Microsoft Word. She had images of a few of the buttons on the blackboard and was making the students memorize them.

Figure 12: Microsoft Word Font Buttons



When I asked her about her teaching practice, her reply was that she needed students to know what the buttons meant before they sat at the computer. When they had some limited one-on-one time with the solo computer available in the classroom, they were able to recognize the buttons and quickly do the assigned task.

Wollard (n.d.) highlighted that behaviorist approach grew into a basis for teaching to ensure that the students learned successfully. Children were told and shown exactly what to do through step by step instruction. Physical activities were used to shape to appropriate position hands, fingers and bodies. Where a child or adult had difficulties with a mouse, for example, a hand could be placed over theirs and moved around or squeezed over their hand, clicking buttons, to demonstrate usage.

Behaviourist learning theory is therefore crucial to the realm of ICT in education, since there are a number of rote-learning behaviours that sometimes need to be learned and exhibited in order to move on to the cognitive aspects of the learning experience.

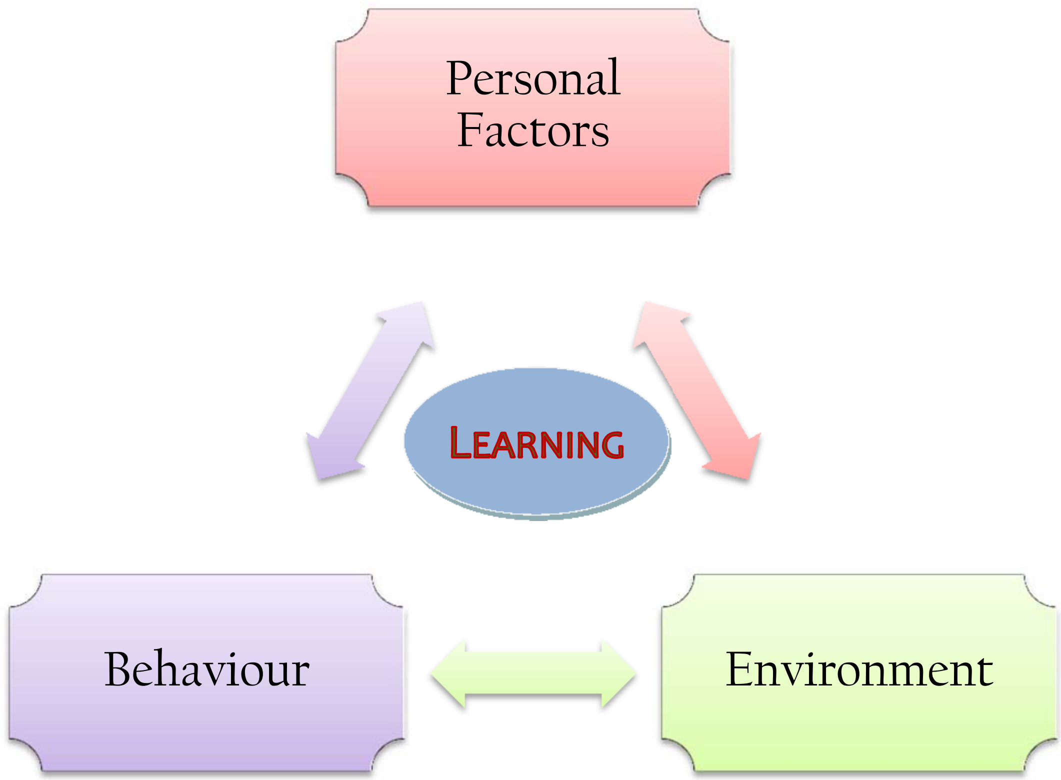
Behavioural theory also has a concrete footing in ICT education development and serves as a foundation to a number of ICT applications. Burton et.al.(1996) stated that in a practical way behavioral theory provides for improvements like teaching machines, computer-based instructions, performance based assistance, minimal competency testing, competency-based education (mastery learning) instructional design, or educational accountability (p.8).

Social-Cognitive theory. Proposed by Albert Bandura (1986), the social cognitive theory (SCT) explains learning as the tripartite relationship between personal, behaviour and environmental factors. The SCT is based on both behavioural and cognitive perspectives since it emphasizes the modeling of behaviour through observing others while also assessing the attitudes and responses that they make. So as students are learning, they are developing an idea of how to behave from the environment around them. Bandura suggested a four step process of how this behaviour is learned –

1. Attention – Here the student observes the behaviour of others in his/her environment.
2. Retention – Now the student retains (remembers) what he/she had observed.
3. Reproduction – This stage is where the student replicates the behaviour he/she had seen and retained.
4. Motivation – Based on environmental feedback, the student decides whether to keep the learned behaviour and/or repeat it in the future.

So basically according to the SCT, learning is the product of the person, observing behaviours while interacting with their environment (Figure 13). In the case of the classroom, the teacher is often the model that the student pays attention to and tries to replicate.

Figure 13: Bandura's Model of Triadic Reciprocal Causation



(Source: Bandura, 1986)

Subsequently a lot of the knowledge is acquired through the teacher, however, the environment of the classroom and the behaviour of other students also play a huge role in the various behaviours retained and reproduced. In the case of ICT, the student observes how a task is done using the technology and then tries to replicate that behaviour to get the required results.

Cognitivist learning theories and ICT. Learning theories based on the cognitivist approach focus on the notion that learners' efforts are the basis for any learning that takes place. This learning occurs when information is actively processed. Having this perception, the teacher should attempt to develop their teaching strategy so that the skills and knowledge acquired by the students are supported by the content used.

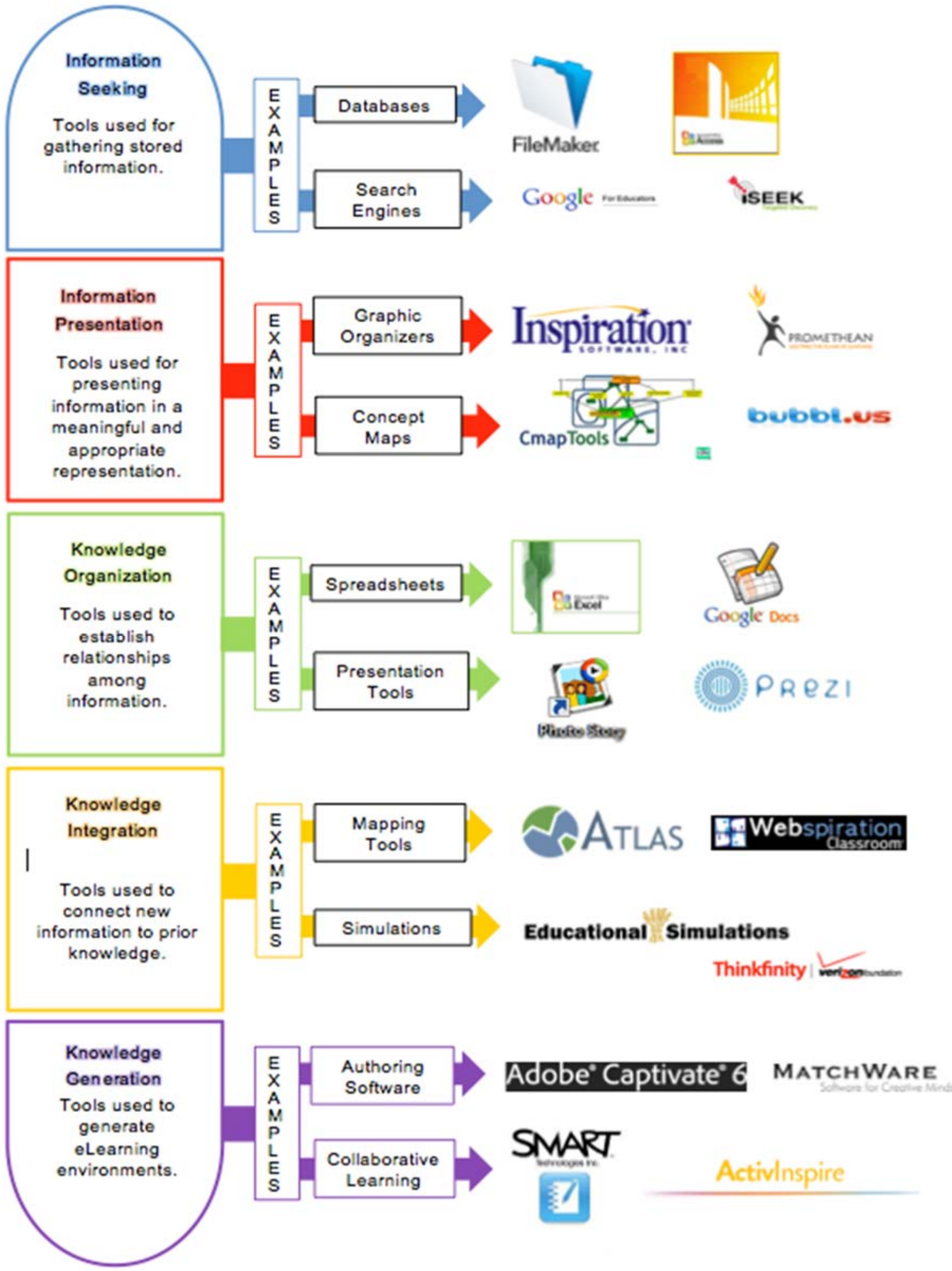
Cognitivism unlike behaviourism incorporates mental events in the study of learning. Students, in cognitive theories are viewed as participants of internal learning which includes memory, thinking, reflection, abstraction, motivation, and meta-cognition (Ally, 2008). Cognitivism, as the outcome of learning, views the gaining of knowledge as a symbolic, mental construction in the mind of the learner. Ertmer and Newby (1993) considered learning to be an alteration of the state of knowledge and essentially a mental activity where an active learner internally codes and structures knowledge (p.58).
They further suggested that the actual aim of the cognitive approach is to change the learner by supporting the use of appropriate learning strategies (p.59). Thus, cognitivists see learners assimilate new knowledge from different aspects of a situation by restructuring existing information and newly acquired information into comprehensible

cognitive structures. According to the Education for Employment Project (2007), since the learner is viewed as an active participant teaching material using demonstrations, illustrative examples and corrective feedback are useful in offering mental models that learners can pursue (p.21).

Ertmer and Newby (1993) suggested specific principles with direct relevance to instructional design. These were: recognizing the learner as active in the learning process; analyzing tasks to identify sequences of skill development - from basic to complex; focusing on the best process by systematizing information; and encouraging the learner to make associations with prior knowledge by appropriately organising the setting of educational environments (p.60).

In order to help learners with complex cognitive learning activities and critical thinking, we can use cognitive tools. These tools are controlled by the learner in the sense that they construct their knowledge themselves using the tools rather than memorizing information. An example of a cognitive tool is a database. Databases allow students to easily complete tiresome and time intensive searches, within seconds. This allows them to spend more time on higher order thinking and less time going through data searching for the relevant information. Hence the database acts as a cognitive tool – it extends the student's mind. Examples of cognitive processes and applications are depicted in Figure 14.

Figure 14: Roles of Cognitive Tools



The Roles of Cognitive Tools, Examples, and Specific Technologies: The image (adapted from Bazluki, Chamberlain, Martin, Mitchell, 2012) lists the 5 roles of cognitive tools followed by examples and specific technologies that demonstrate each role.

(Source: http://projects.coe.uga.edu/epltt/index.php?title=Cognitive_Tools)

Table 5: Cognitive Tools for Teachers

Cognitive Tools for Teachers

Type	Description	Examples
Database	1. Are useful for supplementing the learning of concept-rich content, such as that in geography, social studies, and the sciences 2. Support the storage and retrieval of information in an organized manner Structure is inherent in all knowledge, so using a database that helps learners to structure what they know will facilitate understanding.	Database management systems (DBMSs)
Concept Map	1. Are spatial representations of concepts and their interrelationships that simulate the knowledge structures that humans store in their minds (Jonassen, Beissner, & Yacci, 1993). 2. Are also effective for planning other kinds of productions and knowledge bases.	Inspiration
Spreadsheets	1. Are computerized, numeric record-keeping systems. 2. Qualitatively change educational processes that require manipulation or speculation with numbers and are easy to adapt and modify 3. Support speculation, decision making, and problem solving, and they are often used in what-if analyses. 4. Are versatile tools that are most effective in solving quantitative problems 5. Three primary functions: storing, calculating, and presenting information	Excel
Simulation Tools	1. Represent abstract ideas visually, enabling students to use their most highly developed sensory system. 2. Support performance in investigative projects, so they are scaffolds that enable students to complete projects 3. Help students to understand and express ideas that they otherwise might not be able to.	MacSpartan
Structured Computer Conference	1. Two types : asynchronous communication and synchronous communication 2. Support students to construct their knowledge	Email, Bulletin board service, Discussion board

Shim and Li's (2006) summary of Jonassen's (2006) Cognitive tools for teachers

(Source: http://edutechwiki.unige.ch/en/Cognitive_tool)

Cognitivism is relevant to teachers in their integration of ICT in schools. It helps teachers recognize that when they are faced with problem-solving, with facts and rules applied in unfamiliar situations, cognitivist approaches maybe best. Cognitive tools that can be used by teachers to engage their students are presented in Table 5. However an important point to note according to Jonassen (2006) is that the educator needs to understand and implement the technology in such a way that it helps the students think more effectively and not just interact with the technology for the sake of it.

Constructivist learning theories and ICT. Constructivism is a learning theory describing how people learn and gain knowledge, detailing that people use their experiences to construct meaning and knowledge (i.e. new knowledge is 'constructed' through experience from within, between or among individuals). A more formal description of constructivism considers learning as more than the simple acquiring of knowledge by seeing it as an active, contextualized process of construction. The construction of knowledge occurs through personal experiences and the development of hypotheses about the environment. These theses are repeatedly tested by learners in social negotiations providing each individual with different interpretations and processes for the construction of knowledge. The learner is not simply a blank slate, rather he or she brings previous experiences and cultural factors to a situation (http://www.learning-theories.com). A number of researchers have proposed that constructivism as a learning theory is better suited for successful instruction incorporating technology (Ertmer et.al., 2012; Matusevich, 1995; Overbay et.al., 2010).

A branch of constructivism that is broadly discussed in the field of education is social constructivism. Social constructivism is a variation of cognitive constructivism that highlights the collaborative (social) nature of learning. In social constructivism, the importance of culture and context are highlighted in understanding what takes place in society and in what way knowledge is constructed based on this understanding, continually emphasizing the collaborative nature of learning (Derry, 1999; McMahon, 1997). In order to understand the implications of constructivism and how it may impact the integration of ICT in learning, let us review some of the relevant work done by various researchers and philosophers in the field.

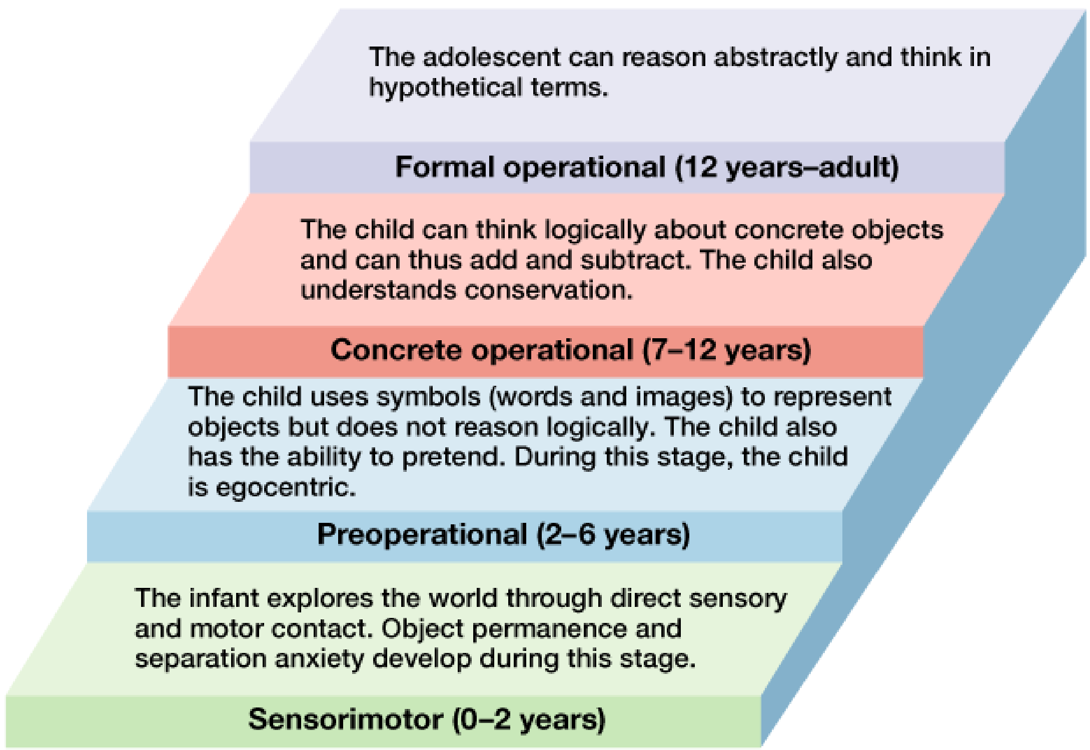
Cognitive constructivism

"The current state of knowledge is a moment in history, changing just as rapidly as the state of knowledge in the past has ever changed and, in many instances, more rapidly."

(Jean Piaget)

Piaget believed that individuals desire a state of cognitive balance and must adapt to their environment. In order to adapt, he presents two components that facilitate the process of adaptation namely, assimilation and accommodation (Dimitriadis & Kamberelis, 2006). Assimilation is an attempt by the individual to interpret the environment in terms of pre-existing cognitive structures. Accommodation takes place when the individual changes their existing cognitive structures to align with reality. Assimilation and accommodation together result in adaptation (Campbell, 2006). However, one important factor that Piaget highlighted was that external input can increase

Figure 15: Piaget's Four Stages of Cognitive Development



(Source: http://appsychologybhs.wikispaces.com/Development)

learning and that knowledge is experience that is acquired through interaction with people, the world and objects around them (DeVries, 1997). Piaget studied cognitive development in children and adolescents where he identified four major stages: sensorimotor, preoperational, concrete operational and formal operational (Figure 15). After observing many children, he theorized that all children progress through the four stages and that they all do so in the same order to advance to the next level of cognitive development.

Piaget's learning theory of cognitive constructivism provides a valuable aide to teachers. Teachers can use this theory to gauge the level of comprehension of each student in the classroom and thereby adapt their teaching methods, tasks, and the language to cater to the needs of the students based on their appropriate level of thinking. This process of adapting instruction to ensure developmental appropriateness provides each student with a higher quality learning experience as well as deeper engagement with the material being learned.

Applying Piaget's learning theory in the facilitation of ICT integration in the classroom, we can see that according to his or her own learning style, each individual assimilates knowledge. Such assimilation in a computer-based learning is founded on discovery and problem solving as new information is related to previously held knowledge (Keramida, 2004 p.7). This assimilation makes Piaget's learning theory indispensable in the integration of ICT since there is more of a focus on learning in a meaningful context in contrast to directly teaching specific skills.

At the early stages of integration of ICT in the classroom, the teacher can find it useful to select and implement technology and software that facilitates learning based on Piaget's concepts. ICT predominantly through multimedia opens up a host of opportunities in this area using interactive software online or through software DVD's. This range of choices will help the child understand and interact with the technology appropriately and with the least amount of hindrance.

It is also important for educators to evaluate software for its developmental appropriateness as the following example illustrates:

When I taught computer uses in education, I had my BEd students evaluate software for developmental appropriateness using Piagetian theory as a lens. I recall one software program designed for pre-school/early elementary called "Shape and Color Rodeo". Students needed to select the correct match for a sequence of shapes, sizes and colors when presented with an array of different shapes in different colors and sizes. Level 1 of the program required students to recognize only one attribute at a time. Many pre-schoolers are in Piaget's pre-operational level of cognitive development would have no difficulty completing this task. At Level 2, students needed to coordinate two attributes simultaneously and three attributes simultaneously at Level 3. Pre-operational learners tend to concentrate on one attribute at a time and would find Levels 2 and 3 beyond their cognitive capabilities. (MacCleave, Sept.9. 2012, Personal Communication).

The first software of its kind, implementing the ideas of Piaget's learning theory was LOGO, developed by Seymour Papert. "LOGO utilizes the recognition and manipulation of colors, shapes, directions, letters, words, and sounds to teach concepts of planning, problem solving, and experimentation. It introduces children to the use of computers. In practice, LOGO involves the manipulation of 'turtles', a form that can be moved around the computer screen, to draw or erase lines" (Grolier, 1993 as cited in Kate Sullivan Elementary School, n.d.).

Examples of recent research in this direction includes the CACHET (Computers and Children's Electronic Toys) project that studied young children's use of interactive toys, the C3 (Children in Chros and Chronos) project which developed game-like collaborative activities that promoted children's spatial-temporal awareness and cognition. (Siraj-Blatchford & Siraj-Blatchford, 2006).

Discovery learning – (Cognitive constructivism)

Education must, be not only a transmission of culture but also a provider of alternative views of the world and a strengthener of the will to explore them.

(Jerome Bruner)

Jerome Bruner is known for his contribution to the practice of education through his advocacy of discovery learning. Bruner developed the idea that all children are naturally curious and when they learn, children construct new concepts or ideas after interacting with their environment, exploring and manipulating objects, mentally grappling with problems, or experimenting by using their current/past knowledge. This experience helps the student retain the knowledge gained since they themselves have discovered it.

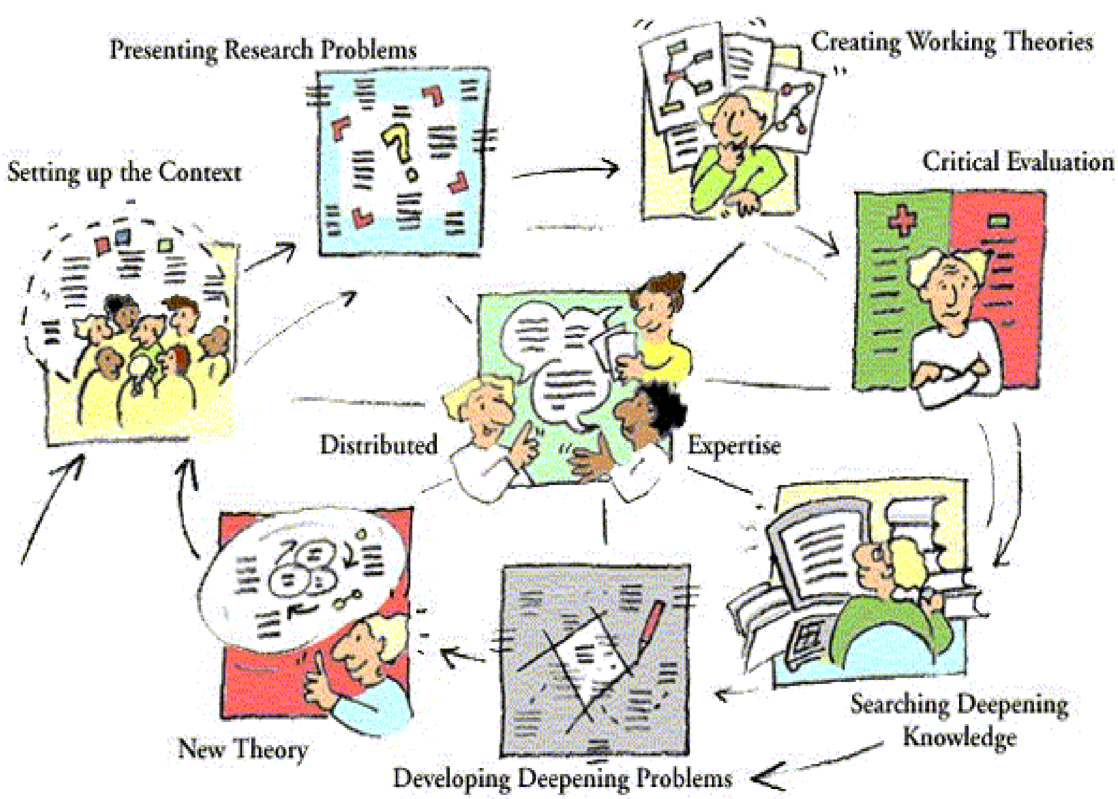
The student selects information, constructs hypotheses, and makes decisions, in the interest of integrating new knowledge into his previously held mental constructs. An example of this sequence is represented in Figure 16. Cognitive structures offer meaning and help organize the knowledge in order to allow transcending the limitations of the given information (Thanasoulas, n.d.).

In essence, Bruner focused on methods with which students could construct (build on) their knowledge in order to learn. He developed a teaching strategy to promote this methodology in the classroom. Bruner (1966) stated that a theory of instruction should address four major aspects:

1. Predisposition towards learning,
2. The ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner,
3. The most effective sequences in which to present material, and
4. The nature and pacing of rewards and punishments.

Since the development of the theory of instruction in 1966, Bruner (1996) has extended his theoretical framework to include the social and cultural aspects of learning in addition to law and its practice. (http://www.instructionaldesign.org/theories/constructivist.html)

Figure 16: Discovery Learning Model



(Source : http://kim-tran.wikispaces.com/Discovery+Learning+Model)

Using the approach of discovery learning, teachers should design their teaching to encourage students to discover as well as engage in problem solving on their own. There are three principles based on discovery learning, first the teacher should focus on integrating material that is interesting and attracts the student's interest to further their understanding by 'discovering' it. Second, teaching and the design of the curriculum should be 'student centered'; that is, it should provide the student with and ideal environment to 'discover' and gain knowledge after assessing the student's current knowledge and capability. Finally, the teaching strategy should be such that it promotes the student to develop their thinking beyond its current state so that newer ideas are developed and their knowledge base is expanded (Bruner, 1966).

According to Jonassen (2000), technologies act as cognitive tools where they allow learners to expand on their thoughts and participate in learning that has a significant value. When integrating ICT in the classroom using a discovery learning approach, we can use teaching models like guided discovery, problem-based learning, simulation-based learning, case-based learning, incidental learning, among others (Robinson, n.d.). Instructional simulation is possible using currently available software like Learning Space, WebCT, Top Class, COSE, Blackboard and so on. Also the availability of games that are based on discovery learning like Jigsaw help the learner use their own knowledge to find solutions to the task given.

Social constructivism

"What the child can do in cooperation today he can do alone tomorrow"

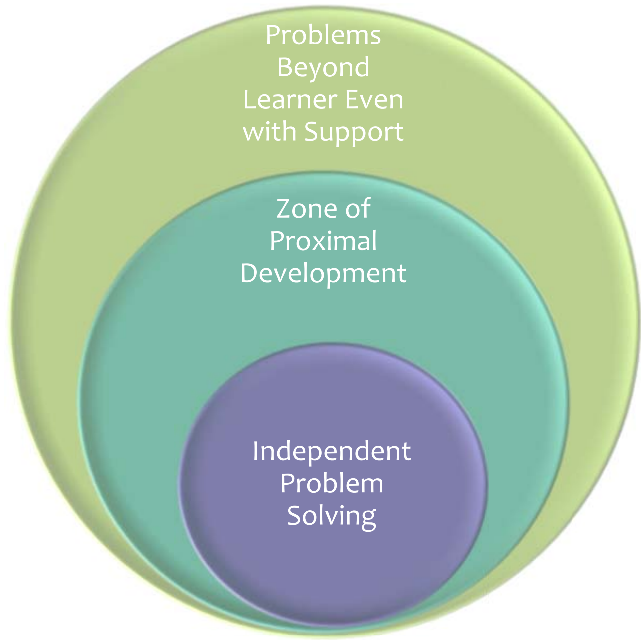
(Lev Vygostsky)

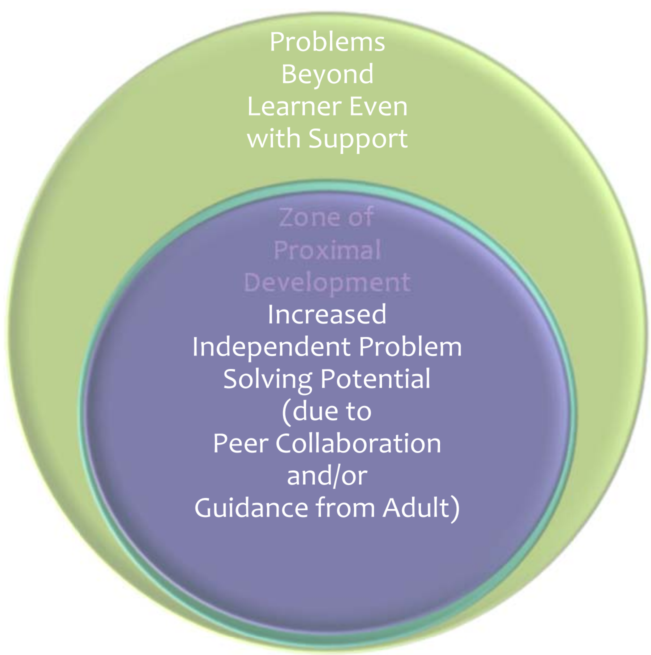
Social constructivism furthers Piaget's view of cognitive constructivism, emphasizing the collaborative nature of learning. Lev Vygotsky is credited with founding and developing the idea of Social constructivism. He theorized that learners improve their knowledge through discussion, dialogue, collaboration, and information sharing (Brodahl, Fagernes & Hadjerrouit, 2007).

Vygotsky (1978), developed the term Zone of Proximal Development (ZPD) which he described as the "distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in association with more capable peers" (p.86). Within this zone, the learner interacts in ways not possible independent of the environment (Belmont, 1989; Salomon, Globerson, & Guterman, 1989). Learners eventually internalise the knowledge exchanged through the supported learning making it part of their own knowledge (Figure 17). When using a Vygotskian approach, ideally a teacher should place learning in the ZPD.

Using a Vygotskian approach, the teacher assists the student by demonstrating, explaining and providing feedback on the material to be learned. The interaction and exchange of knowledge between the student and the teacher provides an opportunity to

Figure 17: Vygotsky's Zone of Proximal Development (ZPD)





the student to increase their independent problem solving capacity by internalizing this new information.

A variety of techniques to support learning and help the learner achieve their objectives have been identified. These techniques are collectively known as scaffolding. According to Ormrod (2012) “scaffolding in its various forms can be highly effective in helping learners acquire complex reasoning, metacognitive, and problem-solving skills” (p. 323). The ability and aptitude of the student decides the kind and level of scaffold he/she may require to succeed, and this varies from student to student. As the student’s proficiency increases, the scaffolding provided is gradually reduced and eventually removed.

One of the purposes of learning is to help students develop higher mental learning processes (Vyogtsky, 1978). In this sense, Vygostky’s social constructivism complements technology use. Classroom computer use can be arranged to facilitate social interaction, expose students to multiple modes of discovering and representing knowledge and encourage them to generate their own products (Dixon-Krauss, 1996). When working in groups with computers, learning becomes a social activity. This theory supports the idea of group learning and is a crucial element of today’s ICT school environment where owing to various reasons learning using ICT is typically shared in groups.

Currently, multimedia interactive ICT can easily support collaborative learning. A good example of research in collaborative learning using ICT is the i3 KidStory project aimed at developing and delivering collaborative storytelling technologies. KidStory offers to create systems that promote the development of skills including creative problem-solving, collaborative learning, expressive design, development of multiple forms of literacy, and exploration initiation (http://www.sics.se/kidstory/research/research_dissemination.html).

CHAPTER 3

METHODS

This study aims to develop a conceptual model for the optimal integration of ICT in the classroom. An exploration of the hindrances that occur with the integration of Information and Communication Technology in the classroom contributed to the model design. More specifically, the current state of integration of ICT in the classroom was reviewed along with issues faced by teachers. Developmental and learning theories that may contribute to a better understanding and resolution of some of the hindrances were also reviewed.

Research Design

The model developed is based on a range of empirical studies presented in the literature review. Many of these studies were large scale surveys covering broad geographical areas. The model itself represents a multidimensional synthesis of facilitating and inhibitory factors encountered when integrating ICT in classrooms. Also included is a fusion of the purposes of learning, different approaches to learning and the structure of groups in a classroom. Paralleling one of the benefits of ICT is the ease with which concepts can be presented in multiple modalities to address variation in students' learning styles; thus, the model will be graphic, visual and conceptual in nature.

Intended Audience

This study was written specifically for educators and also non-educators who are directly or indirectly involved in the practice of education. Since much of what is being presented has a direct impact on the way that teaching and learning occurs within an ICT environment, this study should find relevance with not just student teachers and teacher educators, but also administrators, school board and Department of Education personnel and various other people who are part of the education environment.

Data Collection

The questions guiding this study were revisited and means of addressing each elaborated:

1 What is the current status of ICT in schools?

With the current trends of increasing budgetary constraints and projected economic conditions it is difficult for a large number of educational establishments to provide individual and recent technology adequately to their students (Ali, 2007; Zhao et al., 2002). Studies exploring the current status and trends were summarized from the literature review.

2 What impact does innovation and development in ICT have on the integration of ICT in the school?

With technology, integrating ideas like 'planned obsolescence' as well as advancing and rapidly getting obsolete; for schools, there is an growing gap between the integration of advanced technology and teaching and learning. For teachers, it turns out to be a challenge to integrate this evolving advancement into the classroom, which in turn impacts the student. Systematic analysis of the literature review was done to highlight and summarize the impact.

3 What external factors contribute as barriers to the integration of ICT in the classroom environment?

According to Becta (2004), improper organisation of resources, low quality hardware, inappropriate software, or lack of access, each can influence the ICT usage in schools. Also of importance is the number of students using one computer. According to research conducted by Korte and Hüsing (2007) covering 27 European countries, they observed that a computer was shared on average by 9 students in European schools. In Canadian schools, a median of 5 students per computer was observed (Statistics Canada, 2005). Studies exploring the barriers and external factors that impact ICT integration were summarized from the literature review.

4 What is the current status of ICT integration by teachers in their practice?

One of the more comprehensive surveys about teacher perceptions and use of ICT was the US National Teacher Survey (2005). This study found slightly more than half of teachers (54%) integrated computers into their classroom activities. Even smaller percentages (approximately 25%) perceived their training in the use of current software as adequate and an even smaller percentage (21%) perceived their professional development training in the use of assessment software as adequate.

Research exploring the current status of ICT integration by teachers in their practice was summarized from the literature review.

5 What issues hinder teachers from integrating ICT in their practice?

Lack of skill and/or knowledge as well as issues with integrating ICT into the lesson were cited by Pelgrum (2001) as the top non-material hindrances to developing a successful ICT school environment. Recent research into the barriers to ICT integration in schools also highlights that teacher attitude plays an important role. A teacher's attitude is not just a personal dynamic, but it is strongly influenced by the support and scaffolding available to the teacher in terms of implementing ICT. Another key issue is training. Even in the case where the teacher may have had a formal training in instructional technology, there is a very high chance that they have little to no knowledge on how to translate that training into their teaching practice and curriculum design. (Bauer, 2000; Hardy, 2003). Studies exploring the barriers and issues faced by teachers that impact their ICT integration were summarized from the literature review.

6 How does group instruction impact learning with ICT?

Researching with students at college, Schoenfeld (1989) emphasized the benefits of problem solving in small groups. He claimed that group work encourages a healthy discussion and logical debate of issues and the opportunity to observe and appraise the group's progress. He noted that this experience draws the group closer in their learning and strengthens their commitment to the intellectual values of the discipline. On the other hand, there are issues that arise in groups. According to Flinders University (n.d.), "a common concern in small group teaching is that some students are reluctant to speak. …some students might not understand the need to initiate interaction, or may feel uncomfortable doing so because it is so different from their previous educational experience or because they lack confidence using English publicly" (p.1). Systematic analysis of the literature review was undertaken to highlight and summarize the impact.

7 How might educators develop group instruction to optimize student learning?
This question was addressed through examination of relevant theories of group processes and recommendations presented by them.

8 What can the developmental and learning theories contribute to the integration of ICT in teaching and learning?
Literature was searched to illustrate concrete examples of applications of learning theories in the ICT environment. Although teachers may be familiar with learning theories, they do not necessarily generate connections to practice automatically. That is why it is important to locate and share concrete examples in order to stimulate educators to generate their own applications.

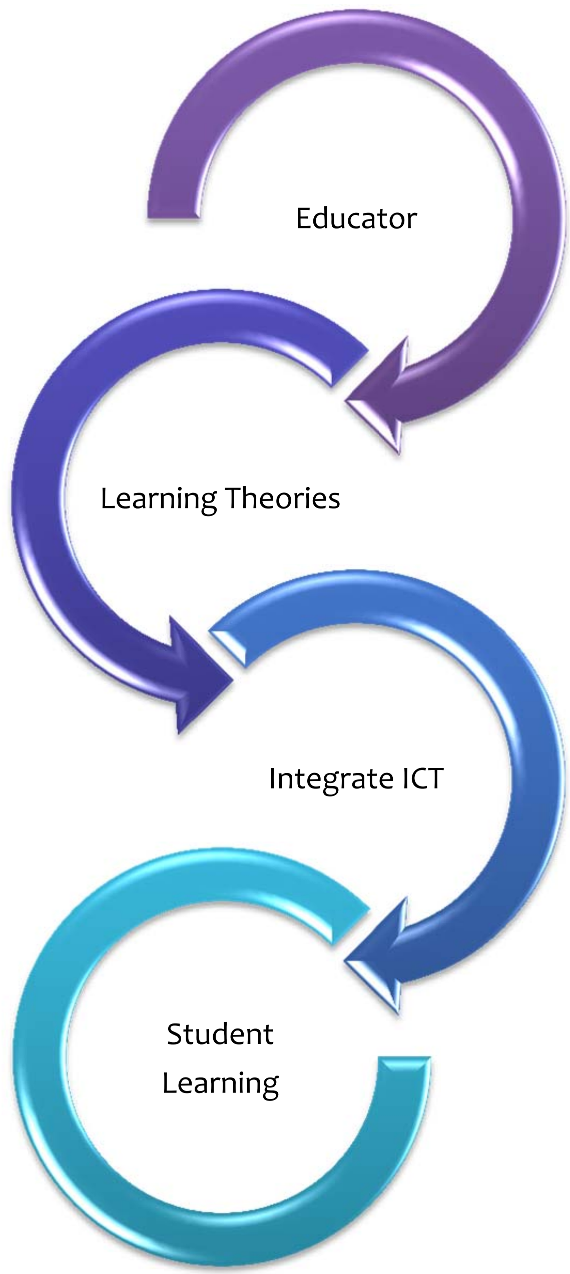
These questions guided me to some specific processes for obtaining and analyzing relevant information. Multiple perspectives were used to answer the suggested questions and these perspectives offered different types of understanding of the posed questions.

Development of the Conceptual Model

Miles and Huberman (1994) defined a conceptual framework as a written or visual presentation that is able to explain graphically or in narrative form the core items to be studied, like the key factors, concepts, or variables, and the understood associations between them (p. 18). The theme of this study was to develop a conceptual framework for better integration and optimal use of ICT for learning in classrooms that have limited access to technology.

Svinicki (2008) further detailed a conceptual framework as “an interconnected set of ideas (theories) about how a particular phenomenon functions or is related to its parts. The framework serves as the basis for understanding the causal or correlational patterns of interconnections across events, ideas, observations, concepts, knowledge, interpretations and other components of experience” (p. 5). The conceptual framework proposed in this study is intended to help educators comprehend some of the key issues that are decisive in teachers’ optimal integration of ICT in classroom when presented with a limited ICT group learning environment. Along with the discussion, a visual representation in Figure 18 portrays the relationships of various model components and their relationship with factors that occur during the integration of ICT in the classroom.

Figure 18: Relationship between the Educator and Student Learning



Five areas were highlighted in the conceptual model:

a. The level of classroom ICT integration attempted by the teacher

b. Knowledge the teacher should have to successfully teach using ICT

c. Learning perspective/theory relevant to the area of ICT to be taught

d. The teacher's role during the area of ICT being addressed

e. Pedagogical approach to facilitate learning

Classroom ICT integration attempted by the teacher. A three layer teaching model was proposed by the Cognition and Technology Group at Vanderbilt [CTGV] (1992) as part of the Jasper Woodbury Problem Solving Series for complex problem generation and problem solving. Parallel to the objectives of this study, the aims of learning that underlie the development of the Jasper series focus on the need to develop all students as independent thinkers and learners instead of simply enhancing the ability to perform basic computations and retrieve factual information. One important element is that students should not simply focus on problems identified by others; rather, they should be able to identify and describe issues of their own finding (CTGV 1992, p.66). The model proposed was - basics first, structured problem solving, and guided generation.

1. <u>Basics First</u> – facilitates the mastering basic skills before solving problems. In the "basics first" teaching model, how to solve problems through sub-skills is demonstrated to students. These problems are then practiced until the student develops the ability to accurately solve them, and then the next sub-skill is introduced in the same way.

2. Structured problem solving - emphasizes the importance of helping students minimize errors and confusion. Here, complex problems are introduced simultaneously with the basic problems, not waiting until the basics have been mastered. This model utilizes the potential of students using their sub-skills in possible complex situations.
3. Guided Generation involves using activities that help students to generate meaningful relationships. Meaningful generation most frequently occurs in relatively complex situations where the sub-goals necessary for solution are not pre-determined. The use of cooperative groups makes the generative learning model easier, because students protect each other from going too far wrong. Nevertheless, teachers often offer guidance to students and even take on the role of a learner. Teachers may not know the answers, but they can help students develop the ability to find them out for themselves. Teachers focus on facilitating students and discussing issues that may be innovative or unknown to both teacher and student. (CTGV 1992, p. 73-76).

The conceptual model incorporated the three phases suggested by the CTGV (1992) covering core knowledge (basics first), application (problem solving) and creativity (guided generation).

Knowledge the teacher should have to successfully teach the topic. Referring back to the research by Pelgrum (2001), lack of skill and/or knowledge and issues with integrating ICT into the lesson were noted as the top non-material hindrances to developing a successful ICT school environment. In order for this situation to change, a number of schools support their staff by training them in the use of ICT. However, Webb (2002) suggested that teachers do not need to overwhelm themselves by trying to know everything about the software but should instead concentrate on the main functions and utilization of the software that helps in problem solving. This idea is important because software is constantly evolving and it is impossible for teachers to keep on top of all the latest features and specifications of all the software packages (as cited in Hadjerrouit, 2009, p.158-159). Hence, ideally it is best to focus on the main functions and principles of the software by gradually phasing in both training and knowledge building.

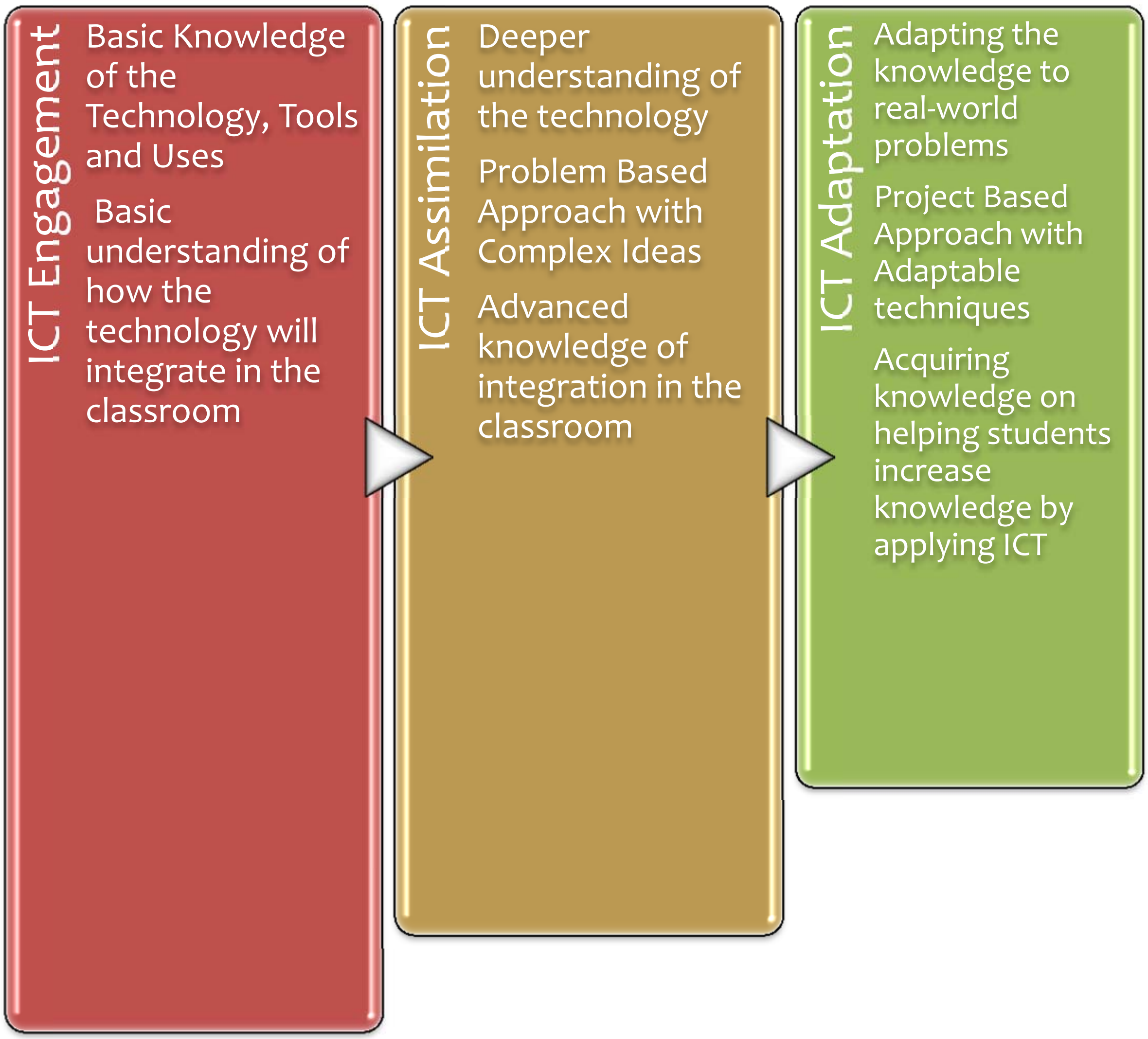
For example, in teaching programming at Carnegie-Mellon University, Shaw (1992) proposed a model that spread the learning of software development into 3 courses.

> First, a junior-level course about the nature of languages and interfaces would introduce programming language structures, 'little languages', and user interface problems. Second, a follow-on course about transducers of programs would cover editors, macro systems, programming environments, test data generation, and program generators as well as compiling techniques sufficient to handle a simple language. Finally, we specified a senior elective for the specialized programming language and topics such as code optimization, fine points of language design, and detailed interactions between languages and their implementations. (p. 2)

By using Figure 19 in ICT learning, we can also phase the training of teachers wishing to integrate a software program into their classroom. The three phases of software learning can be firstly, to introduce the functionality and basic tools that the software and/or hardware can provide along with a basic knowledge of how the technology can be integrated in the classroom. The second phase consists of developing the knowledge acquired previously towards a deeper understanding of the technology. This phase is accomplished by expanding students' knowledge for more complex ideas and problem based approaches as well as increasing their knowledge of how the technology can contribute towards learning. Finally, the goal is for students to learn how to apply the technology to real world situations and project based approaches as well as knowledge of how to use the technology in a variety of situations. Also, part of the final goal is to create a student centered environment by acquiring the knowledge of how to use the technology to help students collaborate, develop their knowledge creation skills and use their knowledge to expand their knowledge base as well as increase their independent problem solving capacity.

The conceptual model will use the phases suggested by Shaw covering ICT engagement (junior-level), ICT assimilation (follow-on) and ICT adaptation (senior-level).

Figure 19: Three Phases of ICT Aquisition

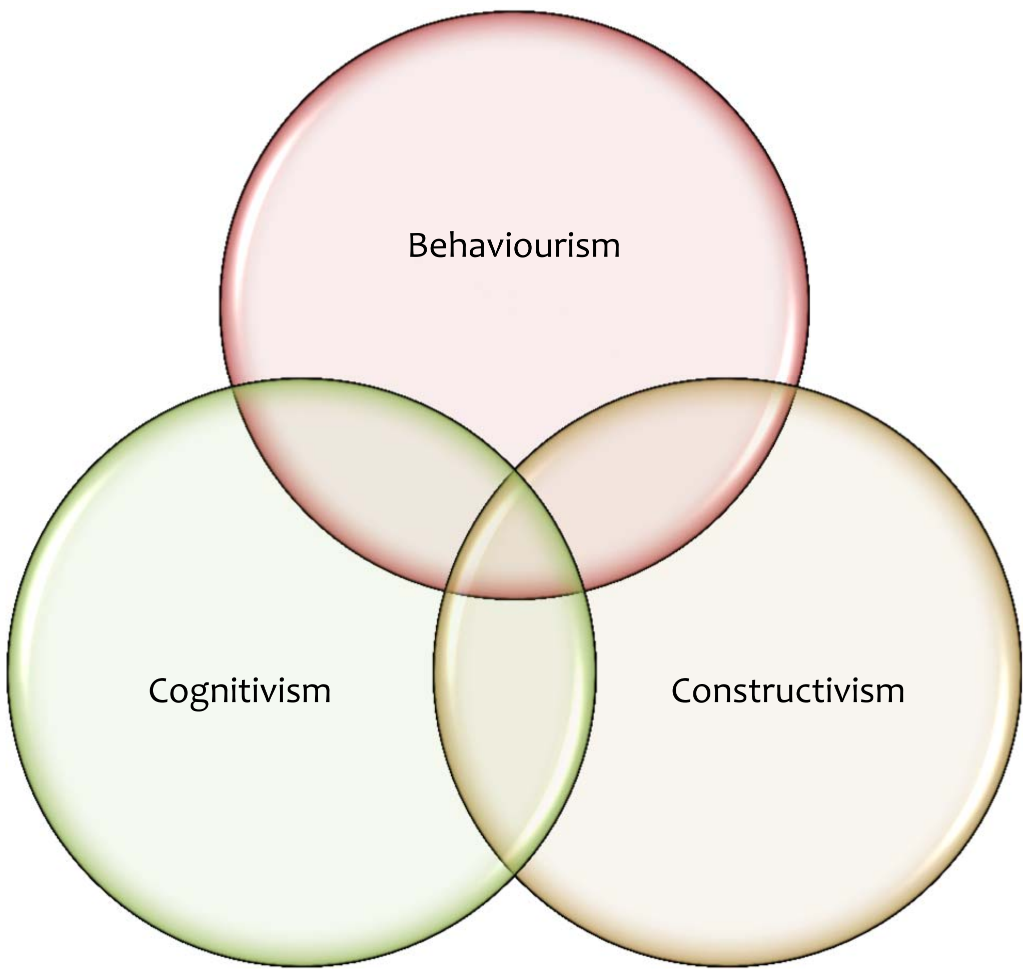


Learning perspective/theory relevant to the area of ICT to be taught. When designing instruction, developmental and learning theories contribute significantly to the integration of ICT in the classroom. As stated by McLeod (2003) when formulating instructions, the comprehension and incorporation of learning theory is important as it focuses attention to the process. Therefore, it is important to address the aims and intentions of formulating instructions to best utilize learning theory in teaching (p.42).

Looking at behaviourist learning theories, it is important to note Shield's (2000) idea that basic or factual information is required for some learning processes in order to internalize more complex processes to further engage in problem solving or other desirable higher-order activities (p.74). Behaviourist learning theory is therefore crucial for the implementation of ICT in education since a number of rote-learning behaviours sometimes need to be learned and exhibited in order to move on to the cognitive aspects of the learning experience.

Cognitive scientists believe that information in computers is processed akin to how humans process information. Ertmer and Newby (1993) stated that the actual aim of the cognitive approach is to change the learner by fostering the use of appropriate learning strategies (p.59). Hence, cognitivists suggest students learn new associations by assessing existing information and structuring new knowledge into comprehensive cognitive structures. Therefore, when designing instruction from a cognitivist perspective, learning objectives are developed by breaking down individual tasks to help reorganise them.

Figure 20: Theoretical Learning Perspective Association



In the case of Constructivism, learning is based on the concept that new knowledge is ‘constructed’ through experience from within, between or among individuals and hence knowledge is either an internal and personal experience or a shared social experience. The results of learning are less tangible and difficult to measure since there can be a variation between students learning the same topic. In the case of a cognitivist constructivist classroom, opportunities should be provided to students so that they can ‘construct’ knowledge from their own experiences. The teacher plays a role which is more of a guide than an instructor. Social constructivism on the other hand, is a variation of cognitive constructivism that highlights the collaborative (social) nature of learning. It highlights the significance of culture and context in understanding what occurs in society and how knowledge is constructed based on this understanding, laying emphasis on the collaborative nature of learning (Derry, 1999; McMahon, 1997). Lev Vygotsky is credited with founding and developing the idea of Social constructivism. He theorized that learners improve their knowledge through discussion, dialogue, collaboration, and information sharing (Brodahl, Fagernes & Hadjerrouit, 2007). Using a Vygotskian approach, the teacher assists the student by demonstrating, explaining and providing feedback on the material to be learned.

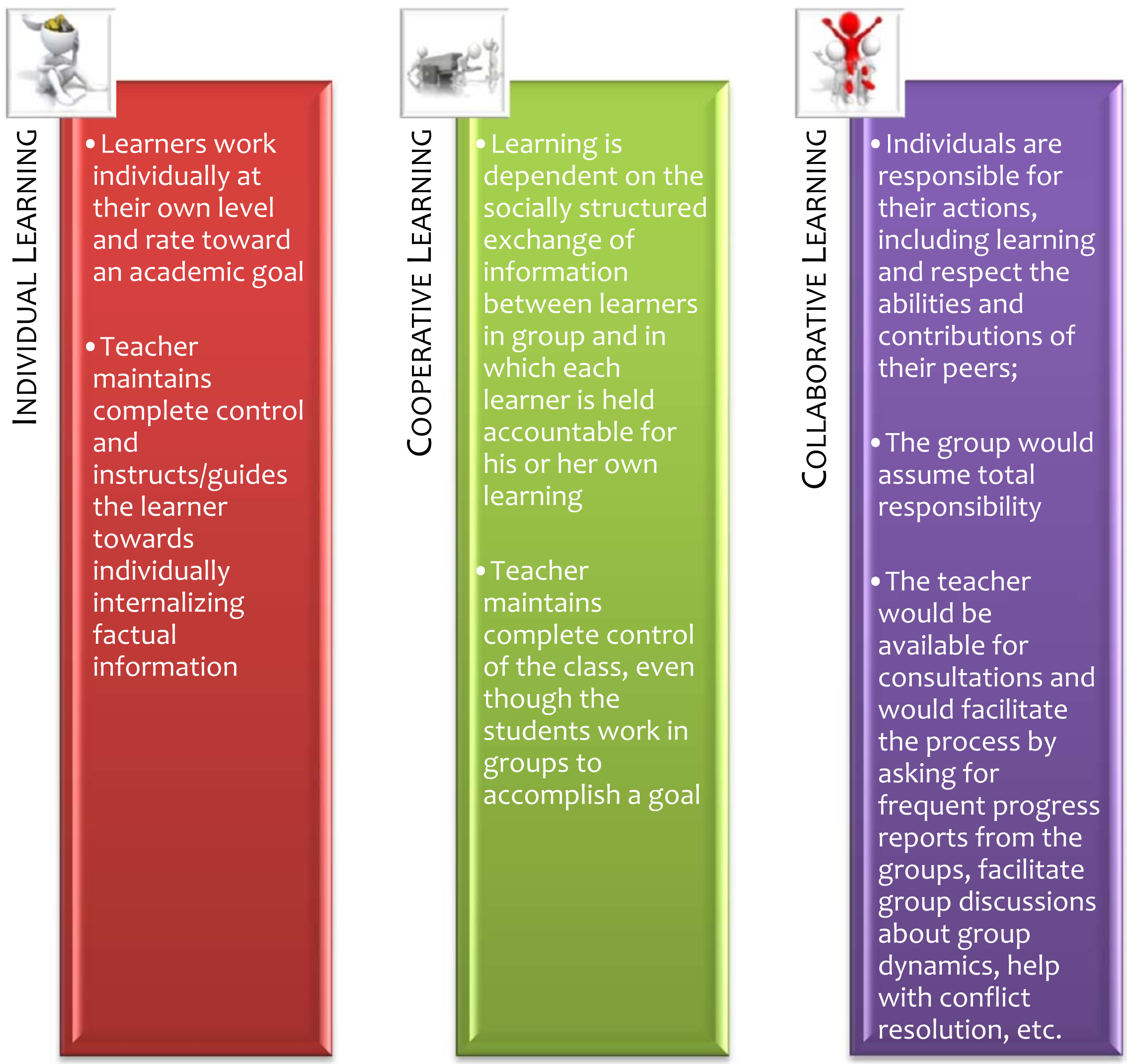
Since the three philosophical frameworks have a strong relationship (Figure 20) with the integration of ICT in the classroom, it is imperative that the conceptual model presents the association of ICT with Behaviourism, Cognitivism and Constructivism (and their associated learning theories).

The teachers' role during the area of ICT being addressed. The role of the teacher varies according to the learning objective. Shield found that different strategies are needed for achieving different outcomes for learning and some of these may need the prior knowledge of certain basic information to learn more complex materials (p.74). The role of the teacher is to assist learning and to make sure that they play the appropriate role in promoting the application of proper learning strategies. From leading a class as an instructor, to assisting knowledge building through discussion, to co-building knowledge by addressing a new topic, a teacher's role changes depending on the knowledge and skill level he/she wishes to emphasize.

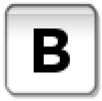
A teacher's role is crucial to the learning and knowledge acquisition of students in the classroom, since each role presents a different approach to the way knowledge is acquired, it is vital that the conceptual model presents the association of ICT with the role the teacher plays during the area/level of ICT being addressed.

Pedagogical approach to facilitate learning. With limited resources at hand and an un-even ICT environment, group instruction is a reality (based on student-computer ratios and other factors) in most classroom environments. According to McCrorie (2006), "group size is probably less important that what the group actually does" (p. 5). Individual learning, cooperative learning and collaborative learning each are instructional strategies that are used in the classroom and, depending on the knowledge level to be addressed; one or more may be used in teaching. For example, a student will need to individually learn

Figure 21: Pedagogical Approaches to Facilitate Learning



(Adapted from Panitz, 1997)

that the  button when clicked will make the highlighted text bold or the text typed from then on will be printed in bold. However, applying the knowledge of the utility of the button can come in handy when the group is given the exercise of making a poster for the class fair in Microsoft Word in a cooperative learning environment or developing a new board game in a cooperative learning environment.

A three mode model for teaching and learning in e-learning environments was proposed by Baumgartner (2004). The three mode were –

To transfer knowledge (Teaching I) –

To acquire, compile, gather knowledge (Teaching II) –

To develop, to invent, to construct knowledge (Teaching III) –

The type of pedagogical approach to facilitate learning can vary based on the material being taught and learning objectives (Figure 21). Since each learning approach presents a different method for acquiring or creating knowledge, it is essential that the conceptual model presents the association of ICT integration in the classroom with appropriate pedagogical approaches.

The five areas discussed were used as the pillars of the conceptual model. These were tied in with the different stages of knowledge acquisition. The association of each of these pillars along with their related stage will then be visually presented and the relationship and dependency among each of them explained.

Ethical Considerations

The MSVU Ethics policy is based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS) which emphasizes continuing commitment by the Agencies to the people of Canada in promoting the ethical conduct in research where humans are involved. It is informed by leading international ethics norms, which may help in guiding Canadian researchers, in Canada and abroad, in the conduct of research involving humans. (TCPS 2010, p.5)

Since this research project has been based predominantly on the literature review and document analysis, a formal ethics review was not required. However, when the model is implemented in classrooms, ethical considerations come into play. For this eventuality, recommendations are attached in Appendix 2.

Validation of the Conceptual Model

Thacker et.al. (2004) explained validation as determining of degree to which a model accurately represents the real world from the viewpoint of its intended use. Different types of validation techniques are available for assessing the validity of the proposed conceptual model. For this particular model, I used the Judgment by Experts technique. To provide a balanced review I used two expert groups so that the validation is "based on consensus among experts in the field (researchers and practitioners)… reflecting the 'collective wisdom' of the field rather than the views of a single person or group" (Moody, D.L. 2005, p. 258)

Hence, I chose the following two groups of experts:

a. Experts in the didactics of Education, Educational Research and Teacher Training
b. Experts involved in the Teaching and Scaffolding of Learning

For this, two faculty members from Education Departments in Canadian universities as well as two teachers in the Maritime school system were requested to participate in the process of validation.

CHAPTER 4

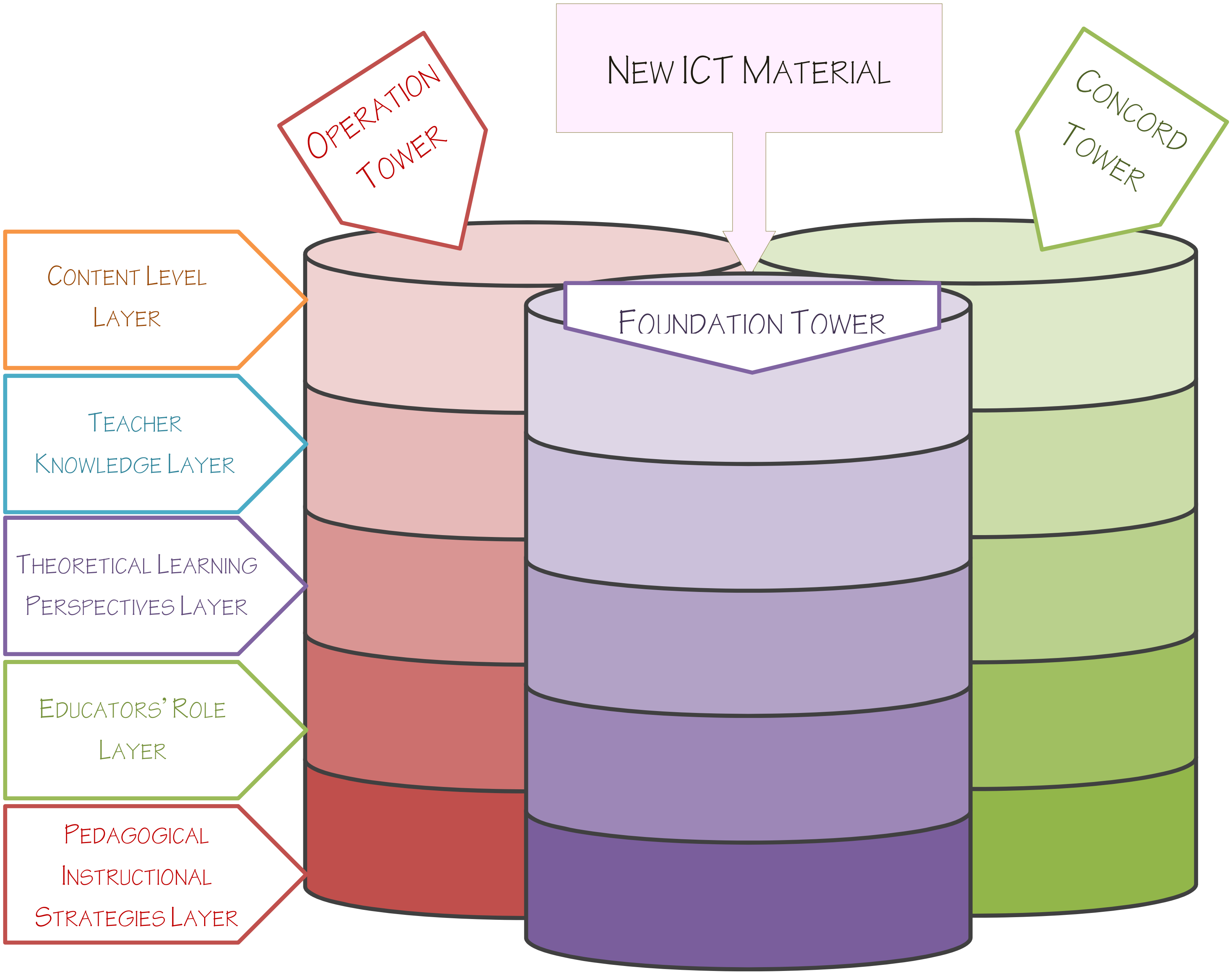
THE MODEL DESIGN

The model is designed in a three dimensional view of three cylindrical towers (Figure 22). It uses the cylindrical shape since the concepts overlap in places and the image can represent that relationship (caused by the overlap) by displaying a Venn diagram view. The cylindrical tower is built up from a stacked sequence of the five key facets of ICT integration identified in the literature review (content to be taught, teacher knowledge, theoretical learning perspectives, role of the educator and pedagogical instructional strategies), that are functionally interconnected.

The interconnectivity among the five key facets and their related components displays a position and logical direction that the educator can then use to better integrate ICT in their classroom. However it is important to note that the model is dynamic and not sequential. So although the towers are stacked on top of one another, each layer is independent of the other and the sequence of the layers can be altered by the educator according to his/her needs.

To present a detailed view of the model, the following pages will consider each key facet and its related components individually. The detailed view will also highlight the relationships between the model components, the position of the overlaps in the concepts and the value and applicability of this overlapping area. Since the model has been designed as a three dimensional object, but is being represented two dimensionally, a

Figure 22: View of the Model



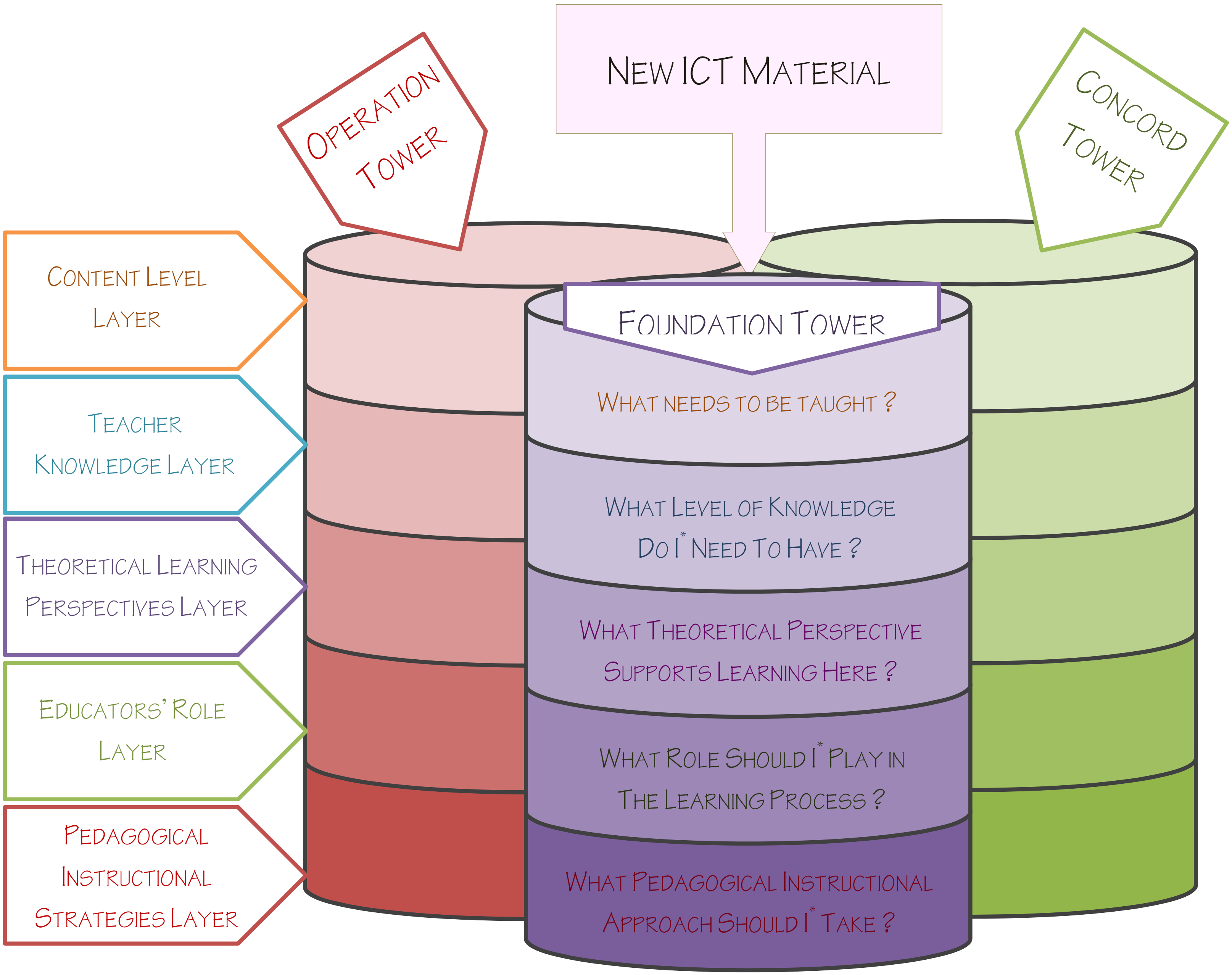
detailed elaboration of the model presented here will split the analysis of the model horizontally and vertically, depicting the interconnectivity and relationship among the various facets and components.

When viewing the model (Figure 23), from a vertical perspective we can see five facets as stacked levels. These are content to be taught, teacher knowledge, theoretical learning perspectives, role of educator and pedagogical instructional strategies (Bauer, 2000; Cognition and Technology Group, 1992; Hardy, 2003; Ormrod, 2012; Shaw, 1992).

What Needs to be Taught?

This question is important to answer for the educators when faced with integrating ICT in their classroom. The questions that arise here identify the level of complexity the educator is teaching about the ICT. It is vital for educators to know the level of expertise their students will attain and understand what they expect to achieve after the integration session. To this end, they first need to assess what material they will be focussing on. This key facet is significant since it sets the stage for the entire process. The educator could be entering the model with a class that has no knowledge of this new ICT or a class that has a bit of prior (foundational level) knowledge from another ICT lesson that could be used or a class with high prior knowledge. Each of these would make variations in what needs to be taught. The cross-sectional description on content level will be discussed in detail later in this chapter.

Figure 23: View of the Model (Five Facets)



What Level of Knowledge do I (Educator) Need to Have?

Once educators have an idea of what needs to be taught, they then need to verify their expertise in the topic. The ADEF (2009) suggested that a teacher should be proficient and competent in key areas in order to integrate ICT in the classroom. In order for this to happen, a number of schools support their staff by training them in the use of ICT. A discussion and in-depth analysis of educator knowledge and training will be highlighted during the cross-sectional description on teacher knowledge later in this chapter.

What Theoretical Perspective Supports Learning Here?

In order to get a grasp of the implications of ICT on the mind, it is crucial for us to understand how people learn and develop their knowledge. Not only will core knowledge of ICT be taught but so also will applications of ICT and its creative integration with academic content in order to benefit learning. So after addressing the content level to be taught and knowledge required to teach it, the educator then needs to become aware of the theoretical perspectives that support the learning environment. This can be accomplished by looking at the relevant learning theory which is an attempt by researchers and philosophers to describe how people learn, helping us understand the inherently complex process of learning. An in-depth analysis of relevant learning theories will be highlighted during the cross-sectional description on theoretical learning perspectives later in this chapter.

What Role should The Educator Play in the Learning Process?

The role of the educator is the next crucial facet in the structure. Since now the model moves to the actual application of the ICT by looking at the mentoring that supports it in the classroom. The educator plays a significant role in assisting learning and making sure to promote the application of proper learning strategies. A detailed discussion of the mentoring techniques will be highlighted during the cross-sectional description on the role of the educator later in this chapter.

What Pedagogical Instructional Approach should The Educator Take?

On understanding the role played by the educator in assisting learning, finally, we look at the pedagogical approaches to instruction. The type of pedagogical approach to facilitate learning can vary based on the material being taught since each learning approach presents a different method for acquiring knowledge. We will examine the pedagogical approaches to instruction during our discussion of the cross-section on pedagogical instructional strategies.

Horizontal Cross-sectional View

When we view the model horizontally, we can see the three components attached to one another representing some sort of relationship in each layer of the five key facets of ICT integration as presented by the literature review. To further detail the model, we will take each horizontal layer independently and examine the relationship among each component in each of the facets since each layer is independent and the model is dynamic and not linear/sequential in nature. This will be followed by a discussion of the points at which these components intersect with one another.

Content level layer. The first horizontal layer is the content level layer. This layer is visually represented in Figures 24 and 25. Here, we use the approach of the three layer teaching model proposed by the Cognition and Technology Group [CTGV] (1992) at Vanderbilt as part of the Jasper Woodbury Problem Solving Series for complex problem generation and problem solving. The three layers suggested by the CTGV (1992) and Shaw (1992) cover: core knowledge (basic first), application (problem solving) and creativity (guided generation). Let us elaborate each of these three layers as well as the overlap in them:

Core knowledge (basic first). Here the educator's focus is to provide the students with the core competencies of working with this technology. The idea is that the student will understand the basic functionality of the technology, the structure, technique and foundational concepts of the technology as well as the capacity of what the technology can and cannot do.

Application (problem solving). Once students have a clear understanding of the core knowledge and have a good grasp of the basics, they can now use that to solve problems (application). The application layer takes the student's understanding and skill to the next level by introducing problems where each of them can apply their core-knowledge and solve the problems.

Figure 24: Content Level Layer as part of the Model

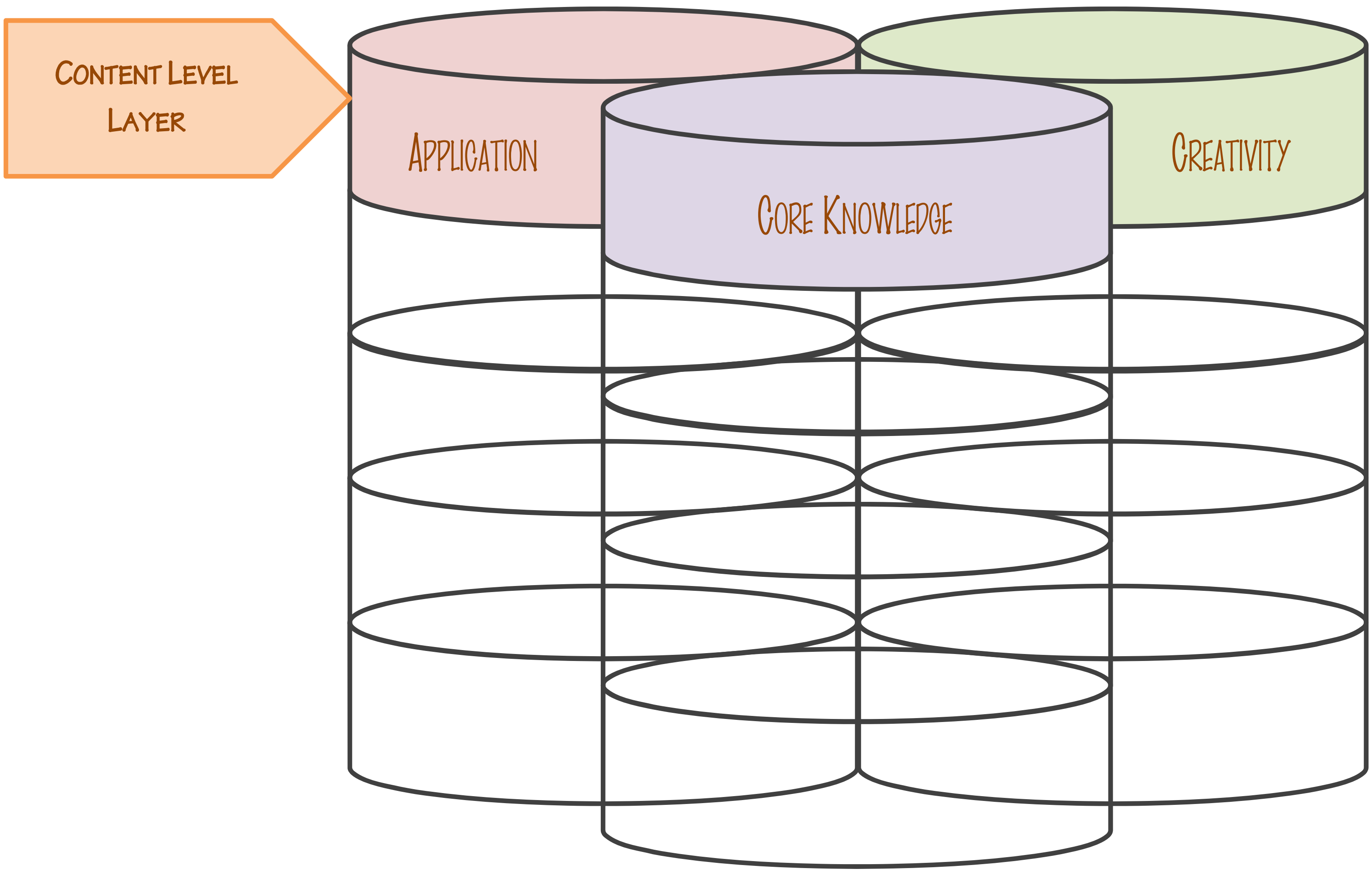
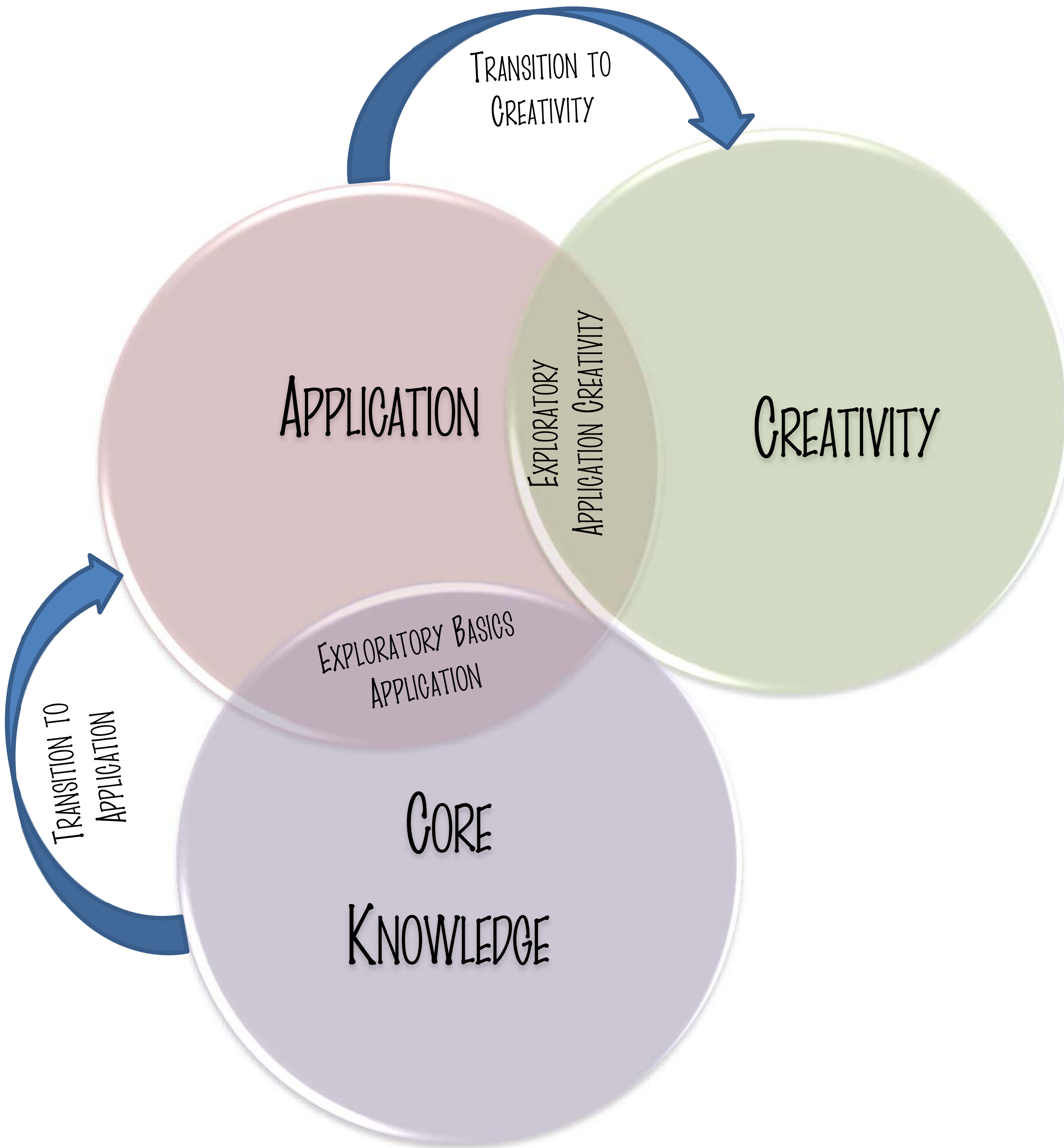


Figure 25: Horizontal Layer Cross-section – Content Level Layer



However, as in the CTGV (1992) approach, the application area overlaps with the core-knowledge area, since the process of application does not stand independently postponed until the core-knowledge is gained and then applied to the problem solving. Once the students have enough core-knowledge (as decided by the teacher), the problem solving process in slowly integrated so that the student can start seeing the applied result of the knowledge and skill they have gained. The overlapping area I have labelled as the *exploratory basics application area*. This label represents students who are still exploring the system with their partial basic knowledge. However, at the same time they have achieved enough skill to apply their knowledge to a problem solving situation.

Creativity (guided generation). Students arrive at the creativity stage once they have achieved the core competencies of working with this technology and have a good understanding of how those competencies can be applied to solve problems. Here, students look at real world problems and situations where this knowledge can be applied and then develop the techniques or processes to solve them. The boundaries are limited to the system and/or software capabilities and the understanding and skill of the students. This stage opens up the learning environment to new and richer learning experiences by sharing and co-constructing knowledge both with the teacher and other students.

Similar to the core knowledge and application areas, there is an overlap between the application area and the creativity area, since the process of creativity starts while the application is being assimilated, skills-mastered and developed. Once the students have enough application knowledge (as decided by the teacher), the creativity process in slowly integrated so that students can start seeing the real world application result of the knowledge and skill they have gained. The overlapping area I have labelled as the *exploratory application creativity area*. At this stage, students are still exploring the different facets of application and have achieved a grasp of a few concepts with their partial application knowledge but at the same time they have achieved enough skill to apply their knowledge to a real world situation.

As is represented visually, there is a very subtle overlap between the creativity area and the core-knowledge area. This overlap represents the learner's ability to bring a previously learned thought process of acquiring skills and knowledge to the next new ICT learning. So although there is no transition between the two stages, there is a shared 'limited' overlap or 'transfer' of learning, to the next phase of learning. According to Perkins and Salomon (1992), "transfer of learning takes place when learning in one context enhances (positive transfer) or undermines (negative transfer) an associated activity in another context" (p.1).

Teacher knowledge layer. The second layer is the teacher knowledge layer. This layer is visually represented in Figures 26 and 27. Here, we use the approach of the model proposed by Shaw (1992) who spread the learning of software development into three courses. Similarly, the model focuses on the main functions and principles of ICT integration by gradually phasing in both training and knowledge building. We can phase the knowledge acquisition and/or training of teachers wishing to integrate ICT program into their classroom into the following three phases: ICT engagement, ICT assimilation and ICT adaptation.

ICT engagement (junior-level). Here the goal is to introduce the functionality and basic tools that the software and/or hardware can provide. The teacher should be able to acquire core knowledge in the specific application. This core knowledge will help the teacher impart the subject matter to students and be able to guide students in their learning the new technology and then use it as a tool to enhance their learning of academic content. The key factor here is that the teacher needs to acquire the skills and basic knowledge of how the technology can be integrated in the classroom. Since just understanding how the technology works may not necessarily translate to a successful implementation in the classroom, there is a very high chance that many teachers have little to no knowledge about how to translate this knowledge and training into their teaching practice and curriculum design (Bauer, 2000; Hardy, 2003).

The idea presented here is engagement, which means that teachers engage themselves with the ICT and start to acquire the necessary foundational knowledge of the technology, its tools, uses and applicability.

ICT assimilation (follow-on). The area adjoining the engagement area is the assimilation area. The assimilation area is where teachers develop the core knowledge they have acquired previously towards a deeper understanding of the technology. This means that teachers start applying their knowledge of the foundational concepts by

Figure 26: Teacher Knowledge Layer as part of the Model

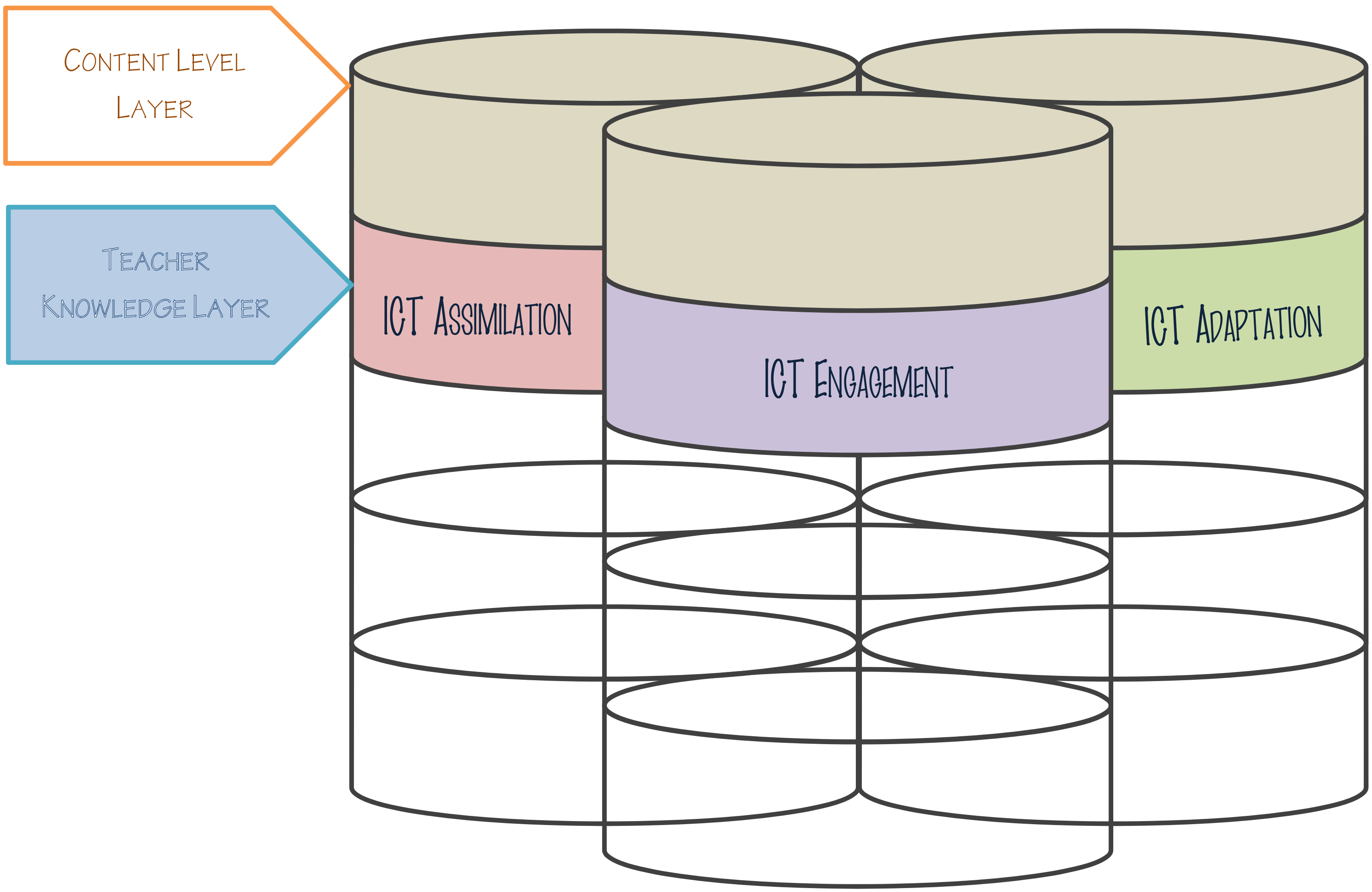
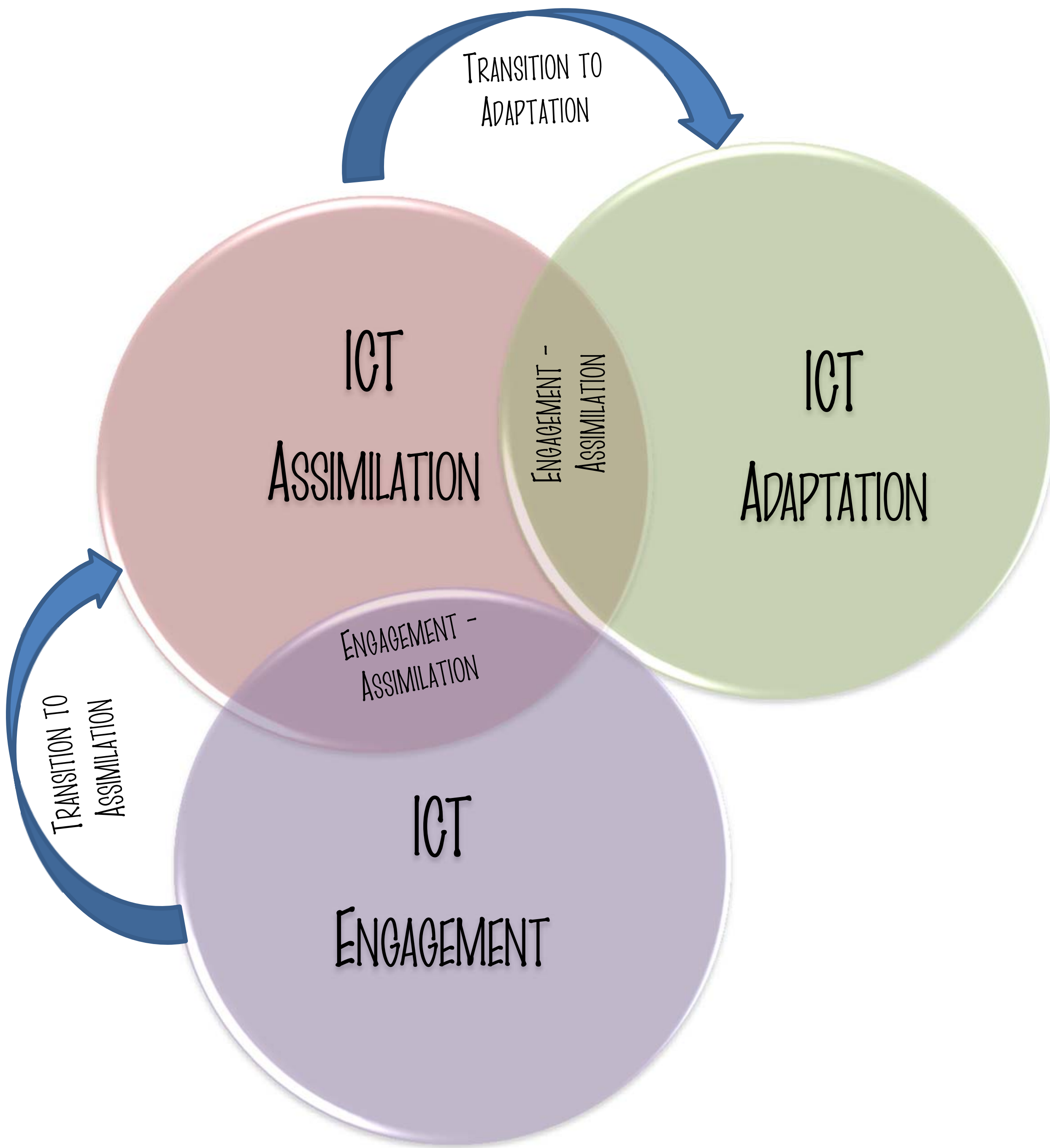


Figure 27: Horizontal Layer Cross-section– Teacher Knowledge Layer



expanding their knowledge application to more complex ideas and problem based approaches as well as increasing their knowledge of how the technology can contribute towards learning.

What is being suggested here is that teachers also need to develop and increase their understanding of how this technology will be integrated, and how different problem solving applications will be presented to the class. It is vital that the knowledge acquired runs hand in hand with the understanding of its implementation and integration in the classroom.

An overlap exists between the engagement area and the assimilation area, since the process of assimilation is a transition from the engagement area. So once a certain level of foundational knowledge is acquired, the overlap occurs where the basic understanding is starting to be applied to problem solving and an understanding is being developed about ways to integrate the technology in the classroom. This overlapping area I have labelled as the *engagement-assimilation area*, since the foundational knowledge is not comprehensive at this point. However the knowledge is at a point where the application of the foundational knowledge to the problem solving domain is possible and is extremely useful since it provides a connection between the theoretical and the applied.

The idea presented here is assimilation, which means that the teacher now comprehends the capabilities of the ICT and starts to build an applied knowledge of the technology, its tools, uses and applicability.

ICT adaptation (senior-level). The teachers transition from the assimilation stage to the adaptation stage when they have a grasp of the applicability of the ICT they are trying to use in the problem solving domain and are able to apply that knowledge to real world situations and project based approaches. They also know how to use the technology in a variety of situations. Also key to this level is the skill in creating a student centered environment by acquiring the knowledge of how to use the technology to help students collaborate, develop their knowledge creation skills and use their knowledge to expand their knowledge base as well as increase their independent problem solving capacity.

An overlap exists between the assimilation area and the adaptation area, since the process of adaptation is a transition from the assimilation area. Once a certain level of skill in applying the foundational knowledge to successfully solve problems is acquired, the overlap occurs when these new skills are starting to be applied to real world problem and new and unique issues. In addition, a greater understanding is being developed of the integration of the technology and its implementation in the classroom. I have labelled this overlapping area as the *assimilation-adaptation area*, since the problem solving skills are not comprehensive at this point. However, these skills are at a point where both the foundational knowledge and its application in problem solving can now be applied in limited real world situations. This stage is extremely useful since it provides a connection between the theoretical, the applied and the real-world.

The idea presented here is adaptation, which means that the teacher now comprehends the capabilities of the ICT and starts to build a real-world applied understanding of the technology, its tools, uses, applicability and versatility.

As is represented visually, there is a very subtle overlap between the adaptation area and the engagement area. This overlap represents the teacher's ability to bring a previously learned understanding of acquiring skills and knowledge to the next new ICT learning. So although there is no transition between the two stages, there is a shared limited overlap or transfer of learning, to the next phase of learning.

Theoretical learning perspectives layer. The third layer is the theoretical learning perspectives layer. This layer is represented visually in Figures 28 and 29. A learning theory is an attempt by researchers and philosophers to describe how people learn, helping us understand the inherently complex process of learning. When designing instruction, developmental and learning theories can contribute significantly to the integration of ICT in the classroom.

According to Ormrod (2012) "by giving us ideas about the mechanisms that underlie human learning and performance, theories can ultimately help us design learning environments and instructional strategies that facilitate human learning to the greatest possible degree" (p.9). The three main philosophical frameworks under which learning theories fall are: Behaviourism, Cognitivism and Constructivism (Kridel, 2010). The model presented restricts the scope of the three learning theories to selected aspects and

Figure 28: Theoretical Learning Perspectives Layer as part of the Model

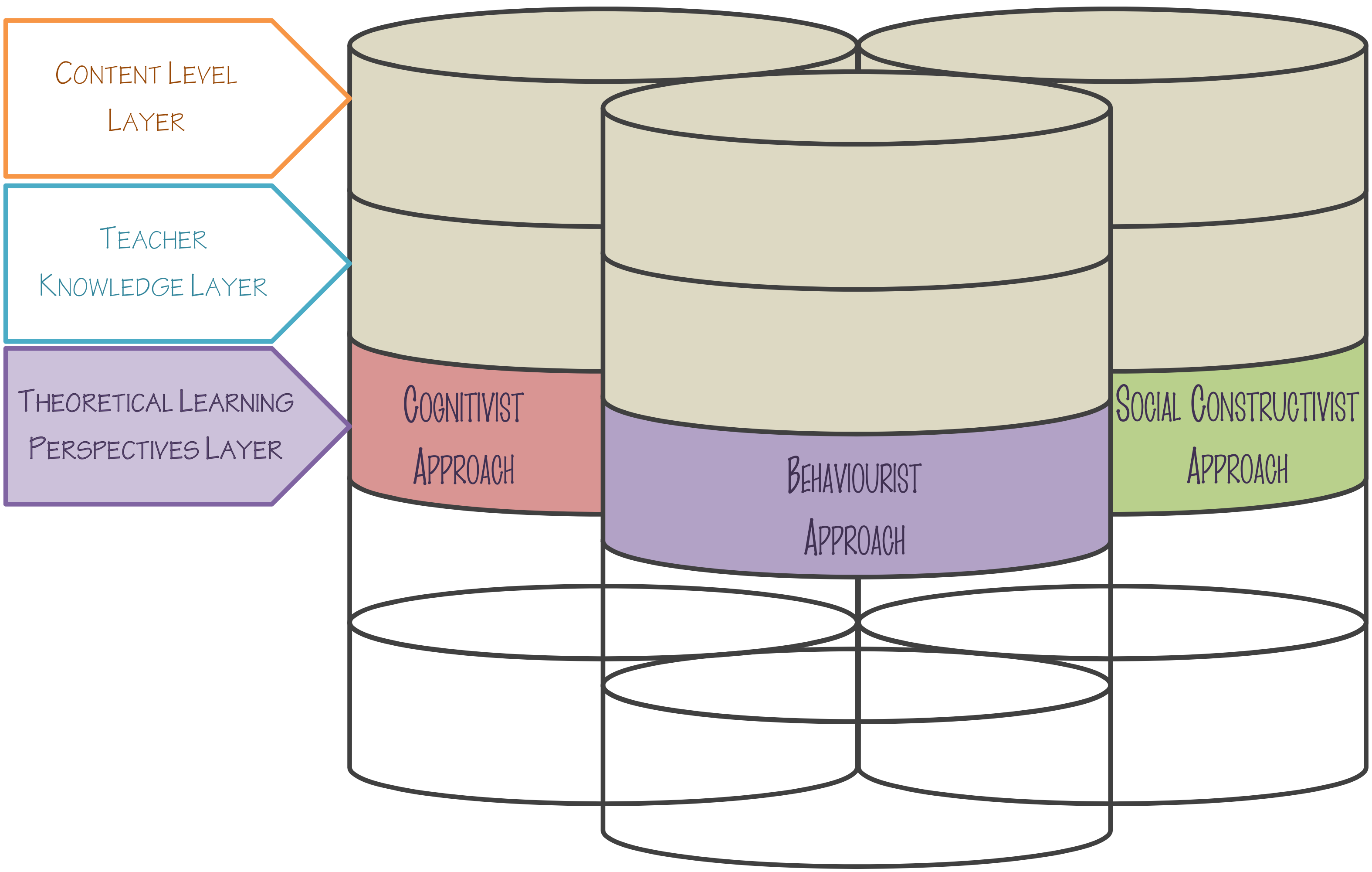
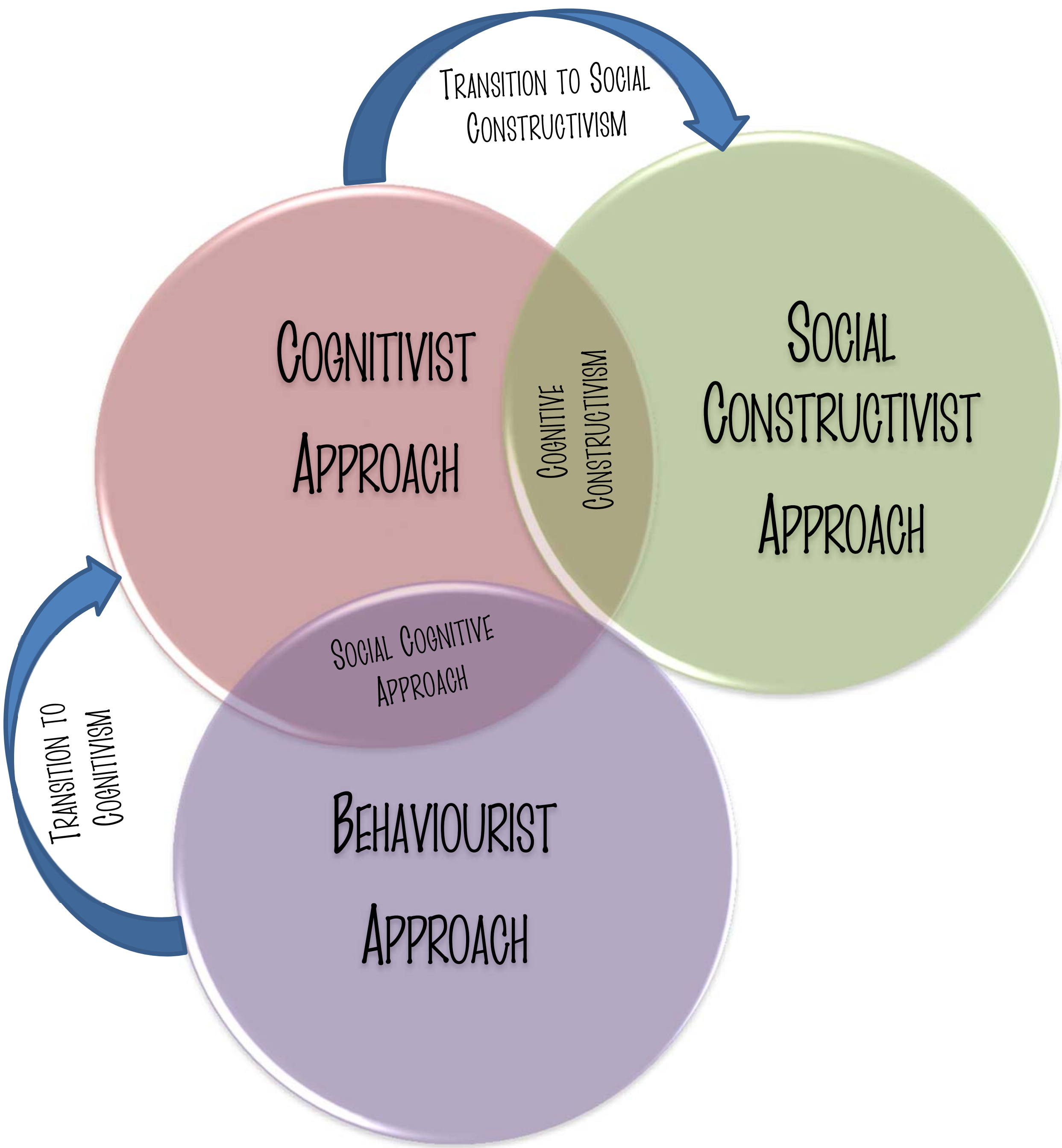
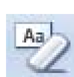


Figure 29: Horizontal Layer Cross-section– Theoretical Learning Perspectives Layer



their applicability in the ICT classroom environment as the – Behaviourist approach, Cognitivist approach and the Constructivist approach.

The Behaviourist Approach. Here the goal is to introduce the functionality and tools that the software and/or hardware provides in the form of shortcuts, buttons and keyboard button combinations or mouse movements. The educator's focus is to provide students with the core competencies of working with this technology. The idea is that the student will understand the basic functionality and foundational concepts of the technology. The key issue here is that when we are introduced to a new technology, the first stage of the interaction has an element of behaviourist learning in it. For example, one of the frequently used software for word processing is Microsoft Word®. When a user is first introduced to the layout of the word processor, there is an entire 1-2 inches of space at the top of the screen dedicated to buttons (with alphabets, lines, numbers, a little clipboard and so on). For an initial user who has had little to no experience with this software, the buttons (which each have a function they perform) may or may not mean anything and a certain amount of memorization is necessary at this stage to help the user in applying the software to his/her use appropriately and efficiently. So the next time the user sees the 

button, he/she may know that clicking it will cause all the formatting of the highlighted area to get cleared. Shield (2000) suggested that there are aspects of learning that need certain basic information if grounding for more complex information is to be internalized. Here the prior factual information is important for the learner to engage in problem solving or preferred complex activities (p.74).

The Cognitivist Approach. Once students have achieved a level of understanding of the core functionality and the tools that the technology affords to the user, they can now use that knowledge to achieve tasks (application). The application layer takes students' understanding and skill to the next level by introducing tasks where each of them can apply his/her functional knowledge and perform the assigned tasks. So once students have transitioned to a cognitivist approach, they can now use the technology as a tool to enhance their learning and achieve a better understanding of the knowledge they are trying to acquire.

When a person learns, cognitive theories focus on the processes that happen in the mind (Ormrod, 2012). The perspective they hold is that information is processed dynamically and we learn and make mental connections between the new material and our existing understanding by conscious mental efforts. For example, students can draw designs and charts and other objects (using the foundational knowledge) that can help them connect to, and visualise an idea or concept. Once they can visualise the idea, they can now manipulate it to improve its design or see potential applications of their idea.

There is an overlap between the behaviourist approach and the cognitivist approach, since the process of applied understanding and reorganisation of information is a transition from the behaviourist approach. So once a certain level of foundational knowledge is acquired, the overlap occurs where the basic understanding is starting to be applied to task achievement and an understanding is being developed about ways to integrate and adapt the foundational knowledge to a more applied environment. This overlapping area represents the theoretical underpinning of the work done by Albert Bandura where his proposed Social-Cognitive Theory states that learning is an inter-relationship between behaviour, environmental and personal factors (Bandura, 1986). Hence based on the theoretical perspective, I have labelled the overlap as the *Social-Cognitive Approach*. Although the foundational knowledge is still not comprehensive at this point, the application of this knowledge to the problem solving domain is possible and is extremely useful since it starts providing a connection between the theoretical, the application and the learning environment (class). The application here is a product of foundational knowledge and personal understanding based on prior knowledge and acquisition of new foundational knowledge. The learning environment provides the opportunity to observe other students and the teacher and then model their behaviours and other attributes. Students learn through observing others' mistakes and successes and then replicating them based on preference.

Social-Constructivist Approach. Students under the framework of social constructivism are at the stage where they have achieved the core competencies of working with the technology and have a good cognitive understanding of those competencies. In the case of social-constructivism, learning is based on the concept that new knowledge is 'constructed' through experience between or among individuals and hence knowledge is more of a shared social and cultural experience. Here, students look at real world problems and situations where this knowledge can be applied and develop the techniques or processes to solve them. This stage opens up the learning environment to new and richer learning experiences by sharing and co-constructing knowledge both with the teacher and other students. At this stage, the only boundaries are limited to the system and/or software capabilities and the understanding and skill of the students.

Similar to the overlap between the behaviourist and cognitivist approaches, there is an overlap between the cognitivist approach and the social-constructivist approach. The process of co-constructing knowledge and problem solving starts while the new knowledge is being assimilated and connected with the existing while new skills are mastered and developed. Once the students have assimilated enough foundational knowledge and developed a sufficient understanding of possible applications (as decided by the teacher), co-construction, social interaction and the gentle reduction of scaffolding or support is slowly integrated. Now, the students can start seeing the real world application as result of the knowledge and skill they have gained and enriched by the exchange of ideas while collaborating to find a solution. The overlapping area draws from the work of Jean Piaget Applying Piaget's learning theory in the facilitation of ICT integration in the classroom, we can see that computer based teaching emphasizes the assimilation of knowledge through discovery of information and problem solving, where students relate new knowledge to what they previously know according to their own learning style (Keramida, 2004 p.7). This overlap makes Piaget's learning theory indispensable since there is more of a focus on learning in a meaningful context in contrast to directly teaching specific skills. Hence, I have labelled the overlap as the *Cognitive –Constructivist approach*. Students at this stage are still exploring the different facets of application and have achieved a grasp of a few concepts with their partial application knowledge but at the same time they have achieved enough skill to enrich and apply their knowledge to a real world situation.

As is represented visually, a very subtle overlap exists between the social-constructivist approach and the behaviourist approach. This overlap represents facets of social sharing of knowledge learned through behaviorist approaches. So although there is no transition between the two stages, there is a transfer of learning, to the next phase of learning.

Educators' role layer. The fourth layer is the Educators' role layer. This layer is represented visually in Figures 30 and 31. The role of teachers is to assist learning and to make sure that they play their appropriate part in promoting the application of proper learning strategies. Associating the teachers' role with the appropriate theoretical learning framework and what needs to be taught provides teachers with a grounded reasoning and clear associations for the role they could play. The three roles that I present in this model are – Instructor, Guided Learning and Co-constructor.

The Instructor. When the teacher's role is viewed as transmitting basics while using a behaviourist approach, the teacher can assume the role of leading a class as an instructor. The educator's primary focus is to provide students with the core competencies of working with this technology. The key issue here is that when we are introduced to a new technology, the first stage of the interaction has an element of behaviourist learning to it.

Figure 30: Educators' Role Layer as part of the Model

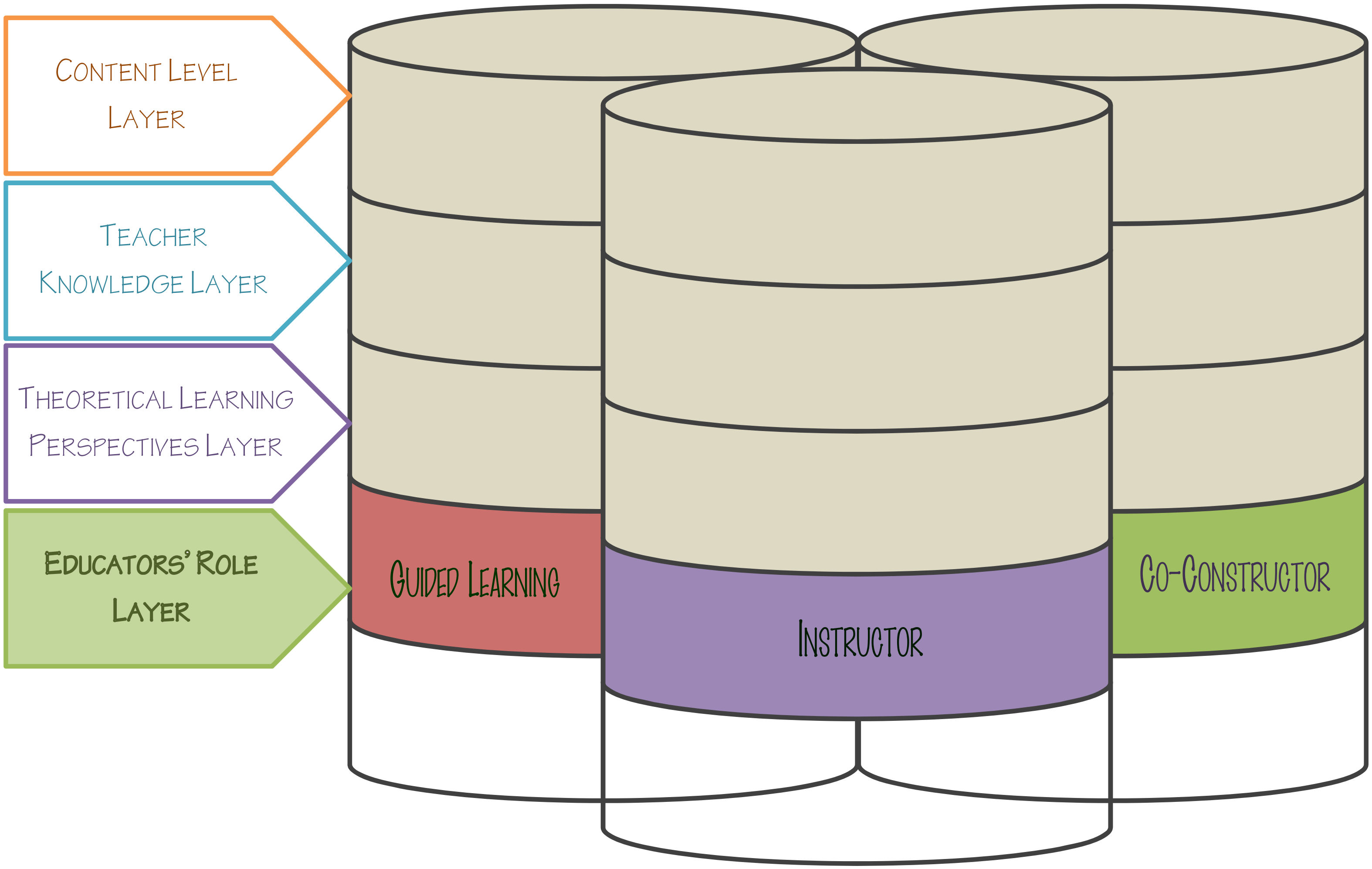
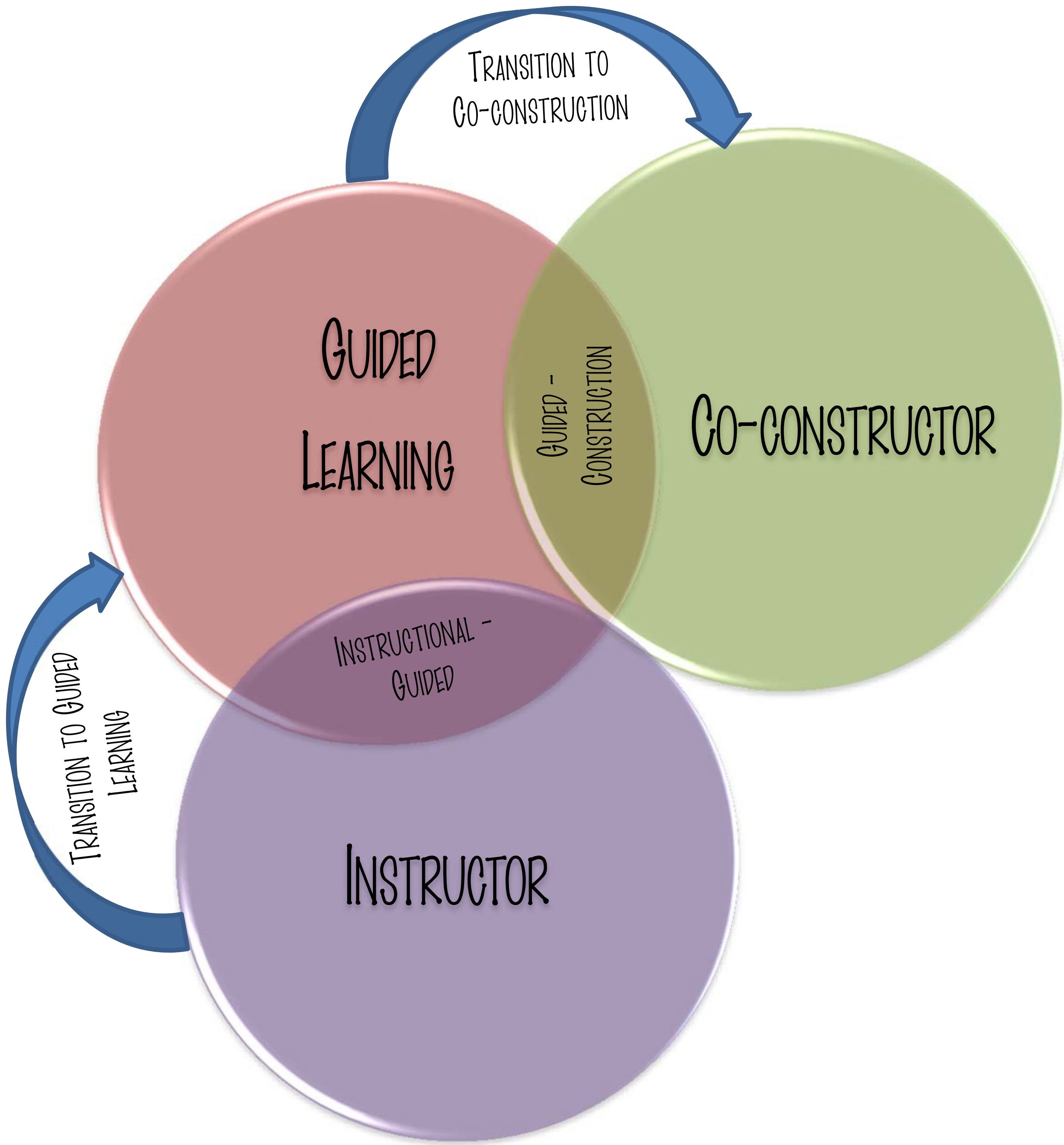


Figure 31: Horizontal Layer Cross-section– Educators' Role Layer



In environments with limited availability of ICT equipment, the teacher as an instructor can present the ICT environment and then continue with a certain amount of "skill and drill" exercises. The teacher can gradually increase the content with guided instruction and a review of the material. Knowledge of how the ICT functions is transmitted from teacher to learner since there is a certain level of skill and technique that needs to be passed on.

To assess knowledge acquired, learning can be tested by reviewing the responses of students to a test or examination. The teacher maintains the role of an instructor until a fundamental understanding of the functionality, technique and structure that this new ICT presents are acquired and a comfort in interacting with the ICT at this level is established.

Guided Learning. The teacher's role, moves to a more guided learning technique when we are looking at developing an applied understanding of the basics. Using the lens of a cognitivist approach, the teacher takes the student's understanding and skill to the next level by introducing problems where each student can apply his/her core-knowledge and solve the problems. When faced with an environment having limited availability of ICT equipment, the teacher can present the ICT environment to a group of students with access to one machine and a problem where students can cooperate. While cooperating, students present their understanding as a contribution to the problem's solution.

However, the teacher's role as an instructor overlaps with the role the teacher plays during guided-learning, since the teacher's role focusing on supporting students learning and cognition does not stand independently nor postponed until the core-knowledge is gained and then applied to the problem solving. Once students have enough foundational knowledge during instruction (as decided by the teacher), the problem solving capacities during the stage of guided-learning are slowly integrated so that students can start seeing the applied result of the knowledge and skill they have gained. The overlapping area I have labelled as the *instructional-guided role,* as represented in Figure 31. This label represents the teacher's role as maintaining a certain degree of knowledge transmission while transitioning into the guided learning role. Here students are still exploring the system with their partial basic knowledge. However, at the same time they have achieved enough skill to apply their knowledge to a problem solving situation.

Co-constructor. At this point, the teacher's role transitions to that of a collaborator. Using the lens of a social-constructivist approach, the teacher takes on the role of a peer and stimulates the process of interaction and discussion. At this stage, students have a good grasp of the foundational knowledge and its problem solving capabilities. So now, students are developing a greater understanding of the employability of the ICT but they need the support of their peers and/or adult guidance to successfully achieve their goals. This stage opens up the learning environment to new and richer learning experiences by sharing and co-constructing knowledge both with the teacher and other students. When faced with an environment having limited availability of ICT equipment, the teacher can present the ICT environment to a group of students with access to one machine. A problem is presented where students can collaborate and the teacher can join in the process as a knowledgeable peer. While collaborating, the students discuss and share their understanding and a collective solution is constructed to solve the problem.

However, the teacher's guided-learning role overlaps with the role the teacher plays as a co-constructor, since the teacher's role focuses on a more social, shared and collaborative environment comes in sequence after supporting students learning and cognition towards applied knowledge. Once students have enough problem solving capacities during the stage of directed-learning, they look at real world problems and situations where this knowledge can be applied and then develop the techniques or processes to solve them. The co-construction process in slowly integrated so that students can start seeing the real world application result of the knowledge and skill they have gained while being scaffolded by the teacher. The overlapping area I have labelled as the *guided-construction role* because students at this stage are still exploring the different facets of application and have achieved a grasp of a few concepts with their partial application knowledge. At the same time, however, they have achieved enough skill to apply their knowledge to a real world situation. So for the teachers, at this stage they need to help students develop their cognition and also demonstrate the richness of co-constructing solutions for real-world problems.

As is represented visually, a very subtle overlap exists between the co-constructor role and the instructor role. This overlap represents the teacher's ability to use the techniques learned as a co-constructor to the next new ICT integration. So although there is no transition between the two stages, there is a transfer of learning, to the next phase of learning.

Pedagogical instructional strategies layer. The fifth layer is the pedagogical instructional strategies layer. This layer is represented visually in Figures 32 and 33. According to Dick et al. (2001), instructional strategy is utilized most often towards various aspects of sorting and organizing the content, outlining teaching activities, and finding the best way to deliver the learning (p.184).

Here, adapting the three mode model for teaching and learning in e-learning environments proposed by Baumgartner (2004), this layer has been designed. The three modes suggested cover – Individual learning (To transfer knowledge -Teaching I), Cooperative learning (To acquire, compile, gather knowledge -Teaching II) and Collaborative learning (To develop, to invent, to construct knowledge -Teaching III).

Individual learning (To transfer knowledge -Teaching I). Here we use the lens of a behaviourist approach, understanding the learners need for factual information and the educator playing the role of an instructor. Since the educator's primary focus is to provide students with the core competencies of working with this technology, the teacher designs the instruction so that students can work individually at their own pace and level. Baumgartner (2004) suggested that this mode works when students encounter new knowledge and need some background factual information in order to ground themselves. This approach is most effective in the teaching of low level knowledge (p.2).

Figure 32: Pedagogical Instructional Strategies Layer as part of the Model

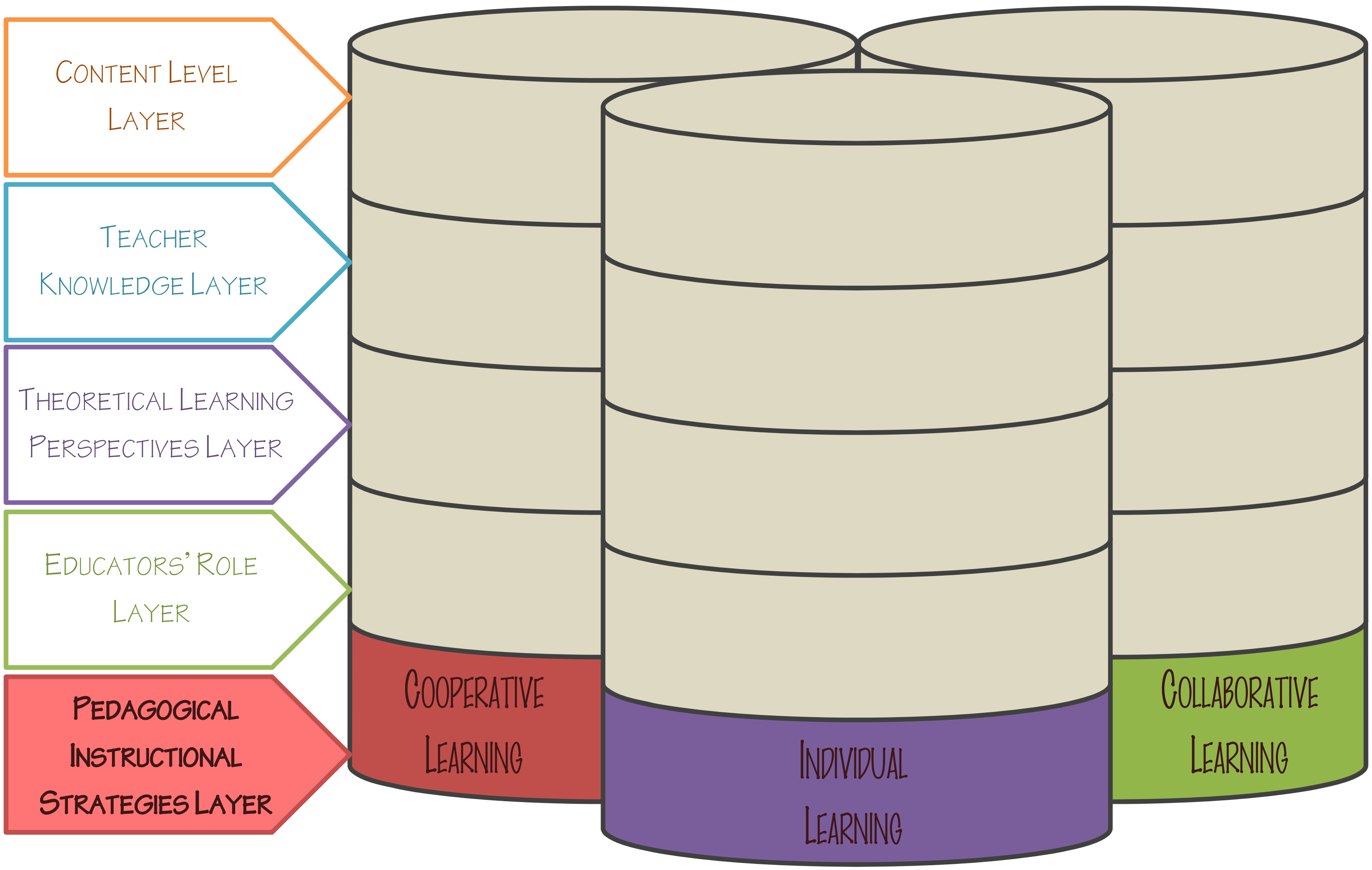
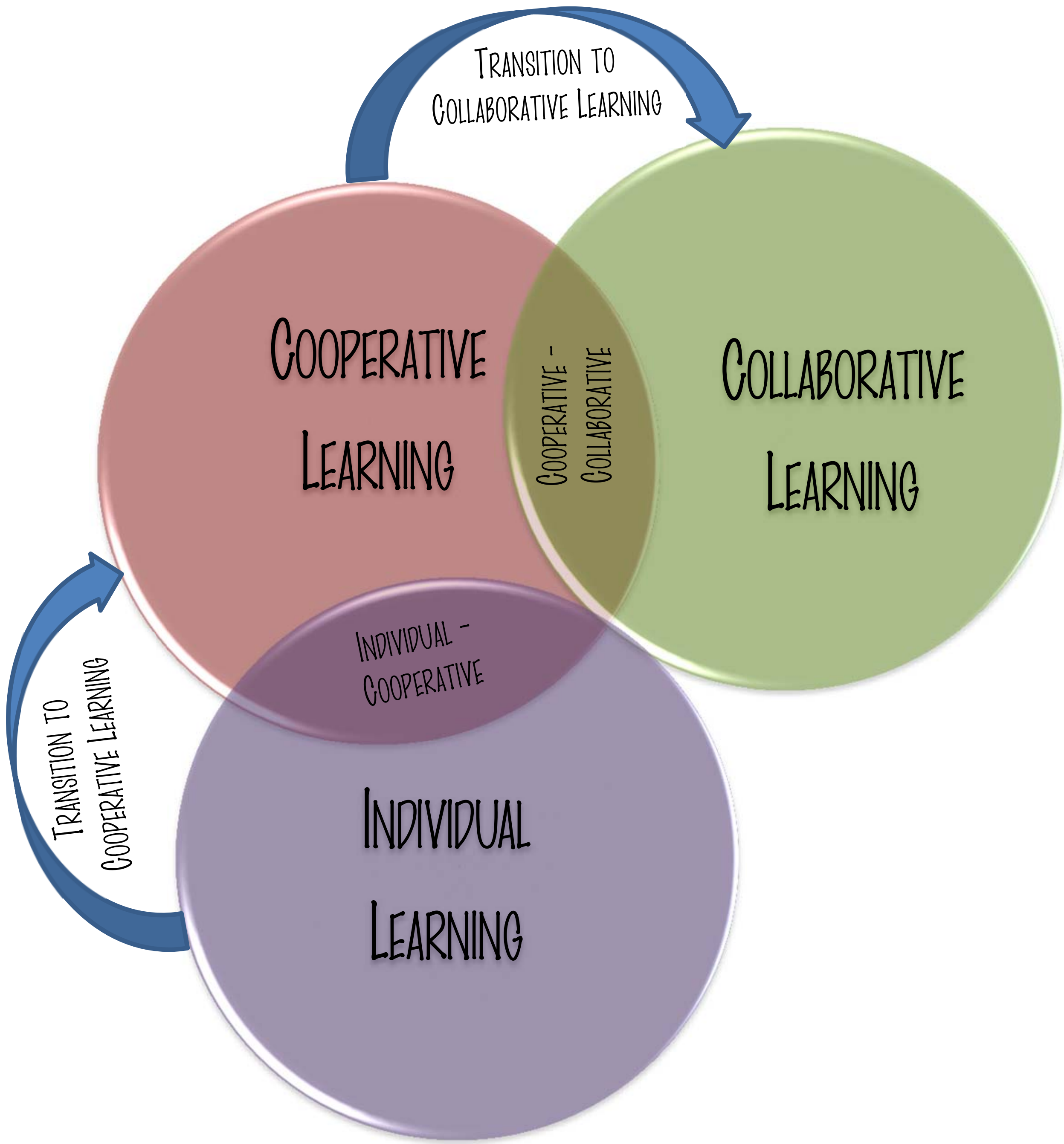


Figure 33: Horizontal Layer Cross-section– Pedagogical Instructional Strategies Layer



Since students need to internalize the basic functionality, the structure, technique and foundational concepts of the technology as well as the capacity of what the technology can and cannot do, the teacher controls the classroom and instructs the student with this knowledge. The format is a more individual learning one, since each student internalises the material at his/her pace and capacity.

Cooperative learning (To acquire, compile, gather knowledge -Teaching II). Using the cognitivist approach where the student can start applying their factual information to problem solving, the educator plays a guided-learning role to facilitate learning. Since the educator's primary focus now is to provide students with the applied understanding of working with this technology, the teacher designs the instruction so that students can work in small groups while contributing their solution to the problem. Students reflect on the problem and then provide their answer to the group. The teacher guides students' understanding and skill to the next level by introducing problems where each of them can apply their core-knowledge and solve the problems as a group, while maintaining control of each stage of the learning process. According to Baumgartner (2004), the teacher creates situations for learning where students learn to collect and compile important information towards solving problems or completing complex tasks. The teacher's role becomes that of one to facilitate the acquisition of necessary knowledge (p.2).

As illustrated in Figure 33, the pedagogical strategy of individual learning overlaps with cooperative learning. Since as the teacher starts supporting cooperative learning, there is still an element of foundational knowledge that needs to be transmitted through individual learning. However students are at a stage where they can use the core-knowledge they have gained so far and apply it to problem solving. This transition is important for students to experience the applied result of the knowledge and skill (individual learning) they have gained. The overlapping area I have labelled as the *individual-cooperative learning*. This label represents the teacher's pedagogical strategy of maintaining a certain degree of knowledge transmission while transitioning into the cooperative learning strategy of developing groups and shared learning.

Collaborative learning (To develop, invent, construct knowledge -Teaching III). Here the social-constructivist approach is best suited. The students are now at a stage where they have a good grasp of the foundational knowledge and its problem solving capabilities. Baumgartner (2004) stated that problem solving was not the main priority, as in the case of cognitivism. It was more important to be able to generate problems in situations that were chaotic, confusing, insecure or unpredictable (p.4) .The teacher takes the role of a peer and stimulates the process of interaction and discussion by being a collaborator. The pedagogical strategy involves splitting students into groups that are given a task and the group takes on the full ownership of the task. However, the teacher always remains on hand to support or advise, ask questions and guide the process. According the Baumgartner (2004), nowadays, teachers are unable to control outright the teaching environment and enter the learning situation along with their students towards unpredictable outcomes. However, teachers have more experience and meta-knowledge to deal with complex learning situations and thus, differ from their students in this respect (p.4).

The collaborative learning pedagogical strategy is well suited for classrooms with limited ICT equipment, since the emphasis in this strategy is on group dynamics, discussion, collaboration and teamwork. So the ICT becomes a shared resource and the focus becomes the ideas and new knowledge generation. Based on Vygotsky's (1978) Zone of Proximal Development (ZPD), the student is in a position to find solutions to problems that they would not have been able to on their own. But now that they have the support of their peers (and if necessary, the teacher) they are able to solve problems that are outside their level of actual development and understanding.

As depicted in Figure 33, the pedagogical strategy of collaborative learning overlaps with cooperative learning. Although as the teacher starts to support collaborative learning, there is still an element of applied knowledge that needs to be acquired through cooperative learning. However the transition can start, since students are at a stage where they discuss and share their understanding (so far) and a collective solution can be constructed to solve the problem. The overlapping area I have labelled as the *cooperative-collaborative learning*. This label represents the teacher's pedagogical strategy of collaboration by taking on the role of a peer and stimulating the process of interaction and discussion while maintaining the cooperative learning strategy of directed-learning for knowledge acquisition and shared problem solving in a group.

Vertical Cross-sectional View

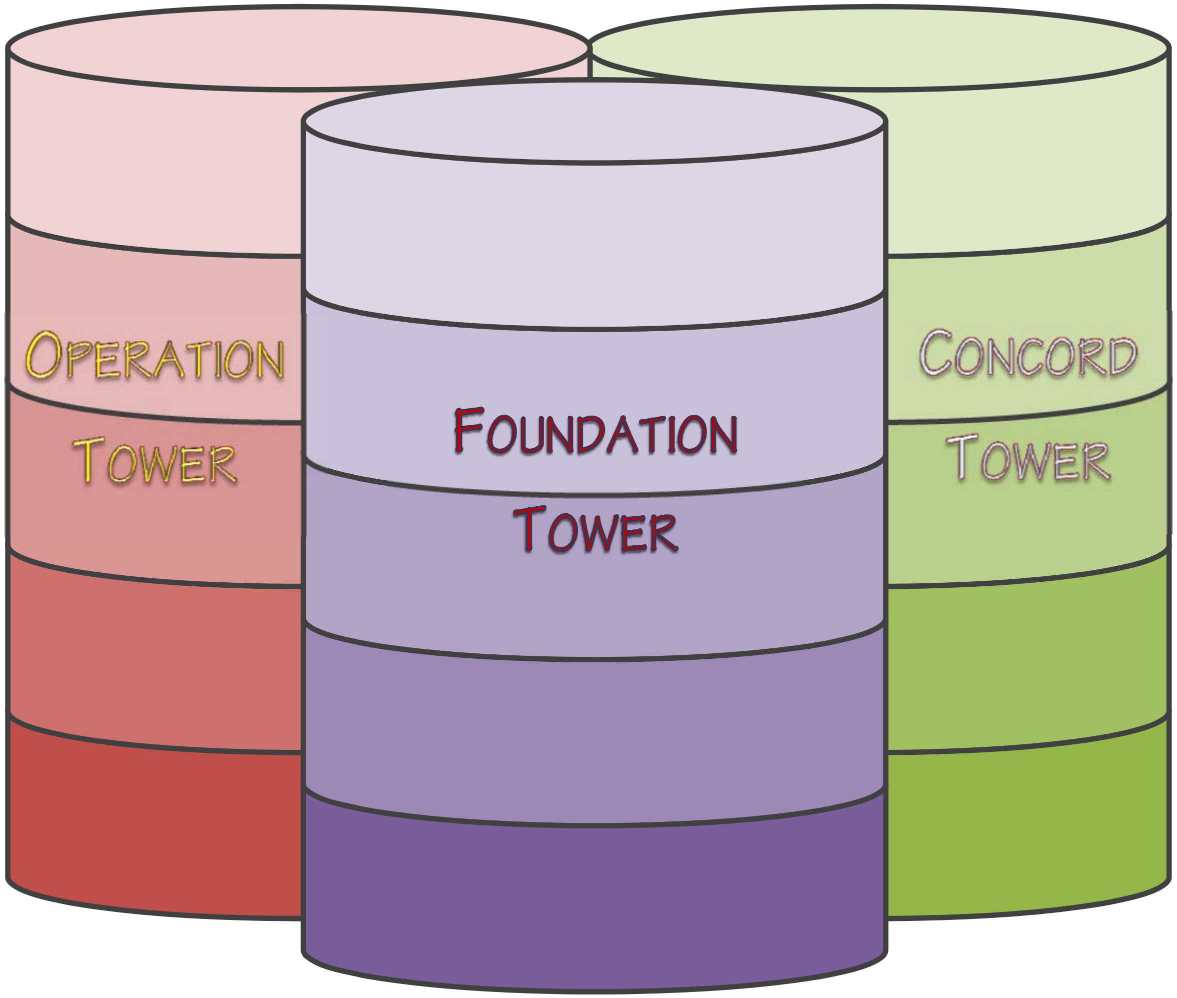
When we view the model vertically, we can see three towers attached to one another representing some sort of relationship in each layer of the five key facets of ICT integration. The tower is visually represented in Figure 34. To further detail the model, we will take each vertical tower independently and examine the association among each of them, followed by a discussion of the points at which these towers overlap. The three towers I have labeled as the – Foundation tower, Operational tower and the Concord tower. The two transition/overlap areas I have labeled as Foundational Anabasis and Operational Anabasis.

Foundation tower. The foundation tower represents the first level knowledge. Each level in the tower represents an answer to foundational questions presented by the five key facets of ICT integration in the classroom based on the literature review presented. The foundation tower is visually represented in Figures 35 and 36.

What needs to be taught?

Core knowledge. Here the educator's focus is to provide students with the core competencies of working with this technology. The idea is that the student will understand the basic functionality, structure, technique and foundational concepts of the technology as well as the capacity of what the technology can and cannot do.

Figure 34: Tower View of the Model



What level of knowledge do I (educator) need to have?

ICT engagement. Since the teacher's goal is to introduce the functionality and basic tools that the software and/or hardware can provide, the teacher should be able to acquire core knowledge in the specific application. The teacher engages him/herself with the ICT and starts to acquire the necessary foundational knowledge of the technology, its tools, uses and applicability. This core knowledge will help the teacher impart the subject matter to students and the ability to guide students in learning the new technology and then using it as a tool to enhance their learning of academic content. The key factor is that the teacher needs to acquire the skills and basic knowledge of how the technology works for their understanding and for the crucial issue of how it can be integrated in the classroom.

What theoretical perspective supports learning here?

The Behaviourist Approach. Shield (2000) suggested that there are a few facets of learning that require certain basic knowledge in order for the individual to internalize more complex information. This basic knowledge is important before an individual can participate in problem solving or other higher-order activities (p.74). The educator's focus is to provide students with the foundational competencies of working with this technology.

What role should I (educator) play in the learning process?

The Instructor. Using the lens of a behaviourist approach, the teacher assumes the role of an instructor. This role is maintained until a fundamental understanding of the

Figure 35: Foundation Tower

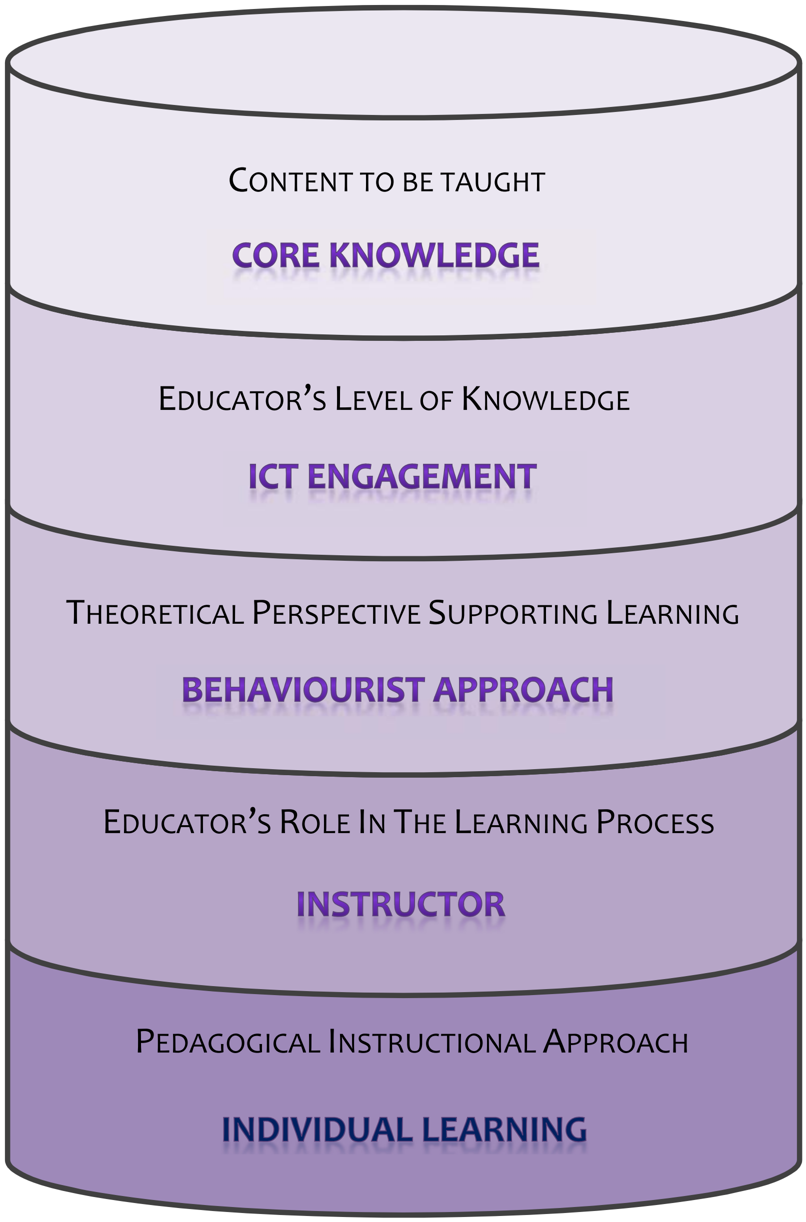
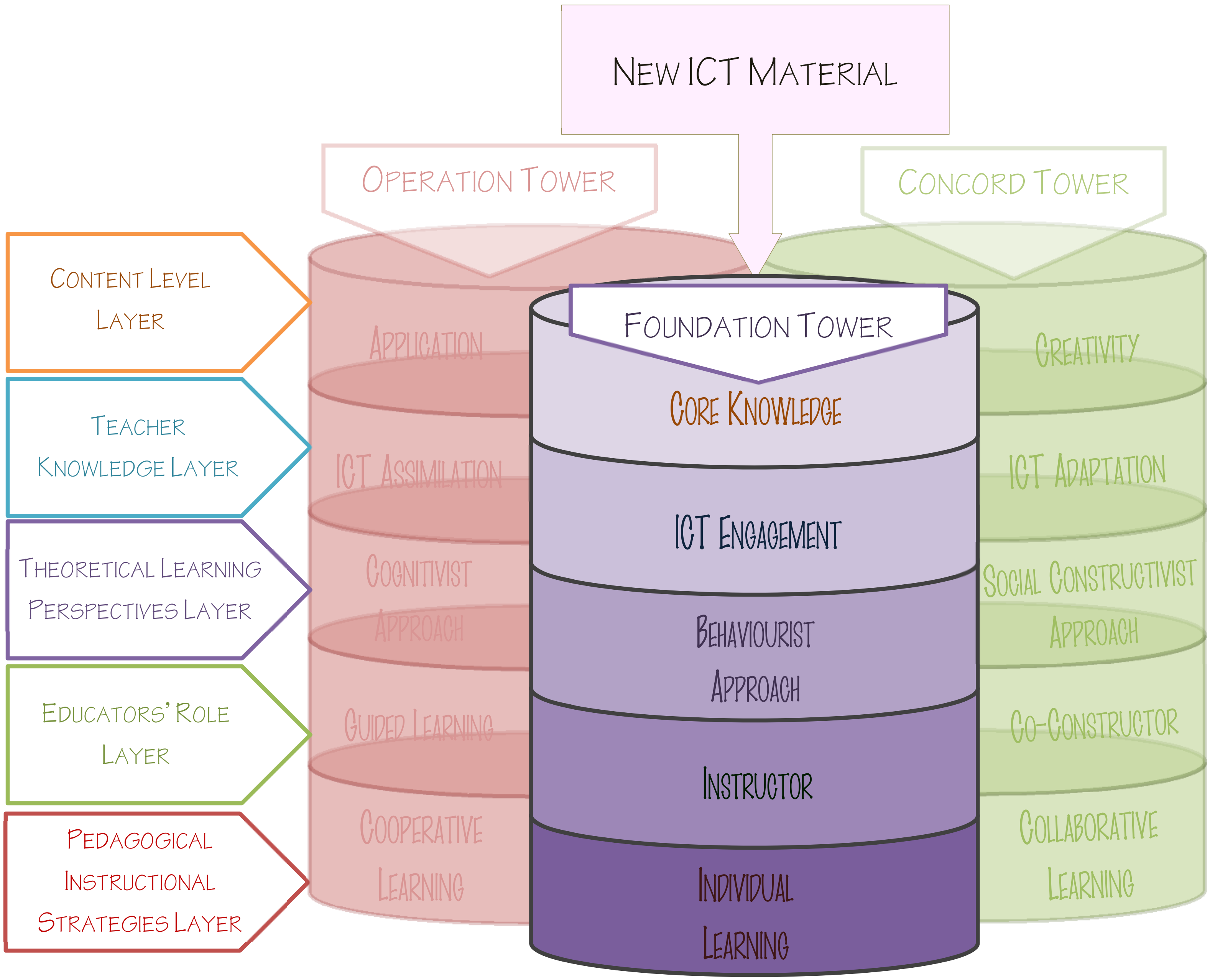


Figure 36: Foundation Tower as part of the Model



functionality, technique and structure that this new ICT presents are acquired and a comfort is established in interacting with the ICT at this level. In environments with limited availability of ICT equipment, as an instructor, the teacher can present the ICT environment, and then continue with a certain amount of "skill and drill" exercises, gradually increasing the content with scaffolded practice and a review of the material. Knowledge of how the ICT functions is transmitted from teacher to learner since there is a certain level of skill and technique that needs to be passed on. To assess knowledge acquired, learning can be tested by reviewing the responses of students to a test or examination.

What pedagogical instructional approach should I take?

Individual learning. Since the educator's primary focus is to provide students with the core competencies of working with this technology, the teacher designs the instruction so that students can work individually at their own pace and level. Baumgartner (2004) suggested that this mode works when students are unfamiliar with discipline and require basic factual knowledge to orient themselves. This method of teaching is acceptable in the learning of low level, static knowledge (p.2). Since students need to internalize the basic functionality of the technology, the teacher controls the classroom and instructs students with this knowledge. The format is a more individual learning one, as the student internalises the content at his/her pace and capacity.

Operational tower. The operational tower represents the next level of knowledge. Each level in the tower represents an answer to operational (application of understanding) questions presented by the five key facets of ICT integration in the classroom based on the literature review. The operational tower is visually represented in Figures 37 and 38.

What needs to be taught?

Application. As students gain a clear understanding of the core knowledge and develop a good grasp of the foundations, they can now use that to solve problems (application). The application layer takes the student's understanding and skill to the next level by introducing problems where each of them can apply their core-knowledge and solve the problems.

What level of knowledge do I (educator) need to have?

ICT assimilation. The idea presented here means that the teacher now comprehends the capabilities of the ICT and starts to build an applied knowledge of the technology, its tools, uses and applicability. At this level, teachers start applying their knowledge of the foundational concepts by expanding their knowledge application to more complex ideas and problem-based approaches. They also increase their knowledge of how the technology can contribute towards learning. What is being suggested here is that teachers also need to develop and increase their understanding of how this technology will be integrated and how different problem solving applications will be presented to the class. It is vital that the knowledge acquired runs hand in hand with the understanding of its implementation and integration in the classroom.

Figure 37: Operational Tower

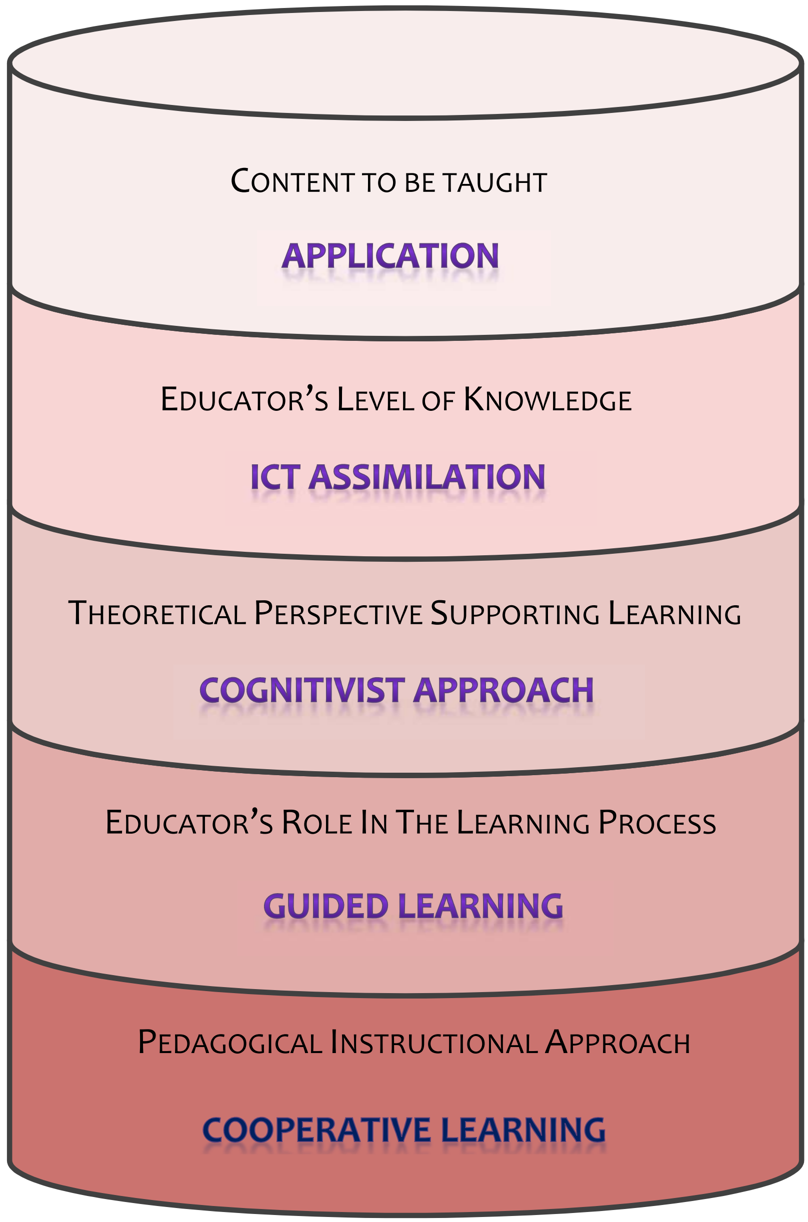
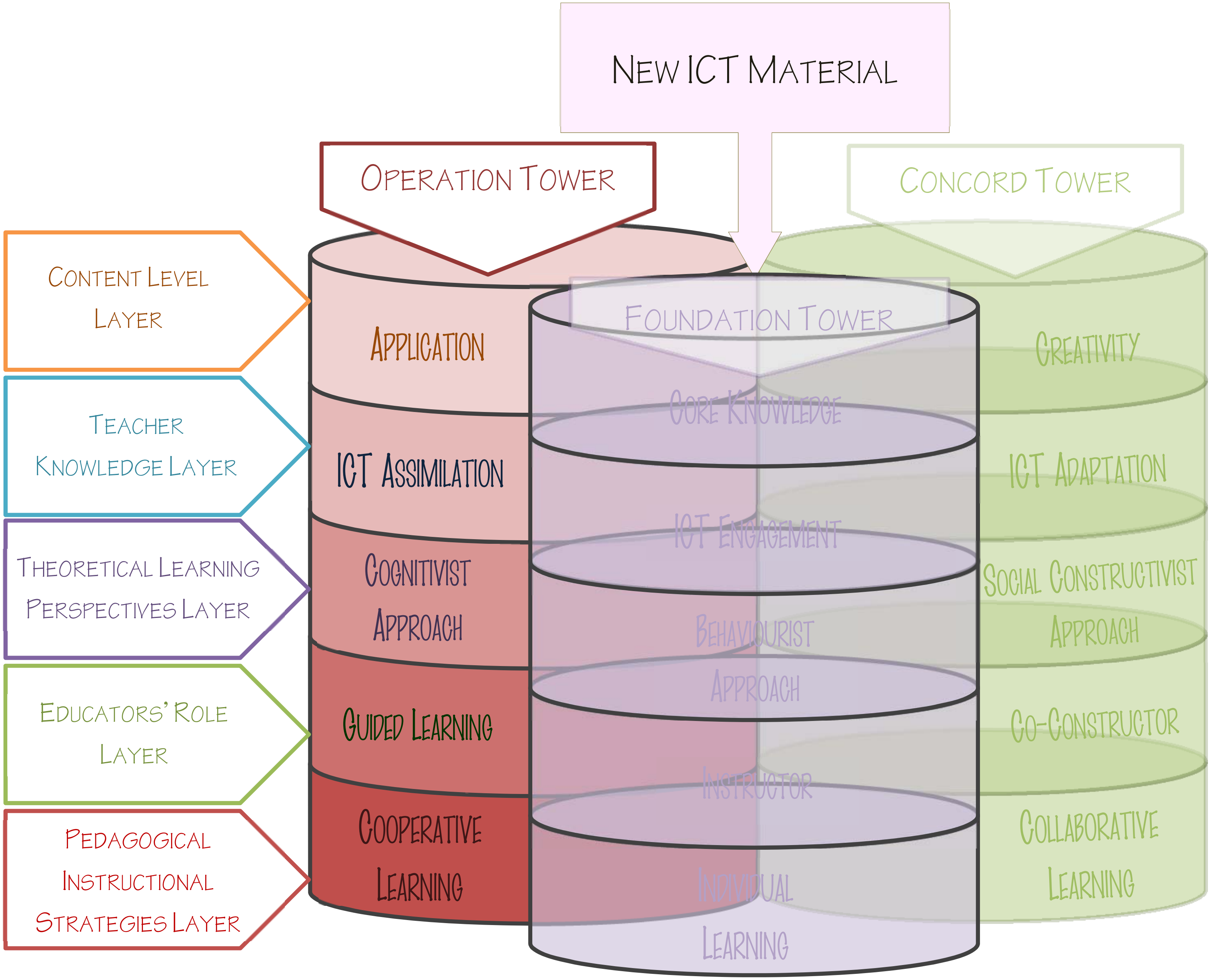


Figure 38: Operation Tower as part of the Model



What theoretical perspective supports learning here?

Cognitivist Approach. When a person learns, cognitive theories focus on the processes that happen in the mind. The perspective they hold is that information is processed dynamically and we learn and make mental connections between the new material and our existing understanding by conscious mental efforts. So, once students have achieved a level of understanding of the core functionality and the tools that the technology affords to the user, they can now use that to achieve tasks (application). The application layer takes students' understanding and skill to the next level by introducing tasks where each of them can apply their functional knowledge and perform the assigned tasks. Consequently once students have transitioned to a cognitivist approach, they can now use the technology as a tool to enhance their learning and achieve a better understanding of the knowledge they are trying to acquire.

What role should I (educator) play in the learning process?

Guided Learning. To facilitate the internalizing of new knowledge (assimilation, adaptation and accommodation) the teacher promotes learning through guided-learning by guiding students towards the problem solution. Using the lens of a cognitivist approach, the teacher takes the student's understanding and skill to the next level by introducing problems where each can apply his/her core-knowledge and solve the problems. When faced with an environment having limited availability of ICT equipment, the teacher can present the ICT environment to a group of students with access to one machine and a problem where students can cooperate. While cooperating, students present their understanding as a contribution to the problem's solution.

What pedagogical instructional approach should I take?

Cooperative learning. The teacher designs the instruction so that students can work in small groups while contributing their solution to the problem since the educator's primary focus now is to provide students with the applied understanding of working with this technology. The students reflect on the problem and then provide their answer to the group. The teacher guides the students' understanding and skill to the next level by introducing problems where each can apply his/her core-knowledge and solve the problems as a group, while maintaining control of each stage of the learning process.

Concord tower. The Concord tower represents the third level of knowledge where the students create solutions to real-world problems. Each level in the tower represents an answer to collaborative (creativity with understanding) questions presented by the five key facets of ICT integration in the classroom based on the literature review. The concord tower is visually represented in Figures 39 and 40.

What needs to be taught?

Creativity. This stage opens up the learning environment to new and richer learning experiences by sharing and co-constructing knowledge both with the teacher and other students. Here students look at real world problems and situations where this knowledge can be applied and then develop the techniques or processes to solve them. The boundaries are limited to the system and/or software capabilities and the understanding and skill of the students.

What level of knowledge do I (educator) need to have?

ICT adaptation. The teacher now comprehends the capabilities of the ICT and starts to build a real-world applied understanding of the technology, its tools, uses, applicability and versatility. The teachers' transition to the adaptation stage when they have a grasp of the applicability of the ICT and are now able to apply that knowledge to real world situations and project-based approaches. They also know how to use the technology in a variety of situations. Also key to this level is the skill in creating a student centered environment by acquiring the knowledge of how to use the technology to help students collaborate, develop their knowledge creation skills and use their knowledge to expand their understanding and increase their independent problem solving capacity.

What theoretical perspective supports learning here?

Social-constructivist approach. In the case of social-constructivism, learning is based on the concept that new knowledge is 'constructed' through experience from between, among and within individuals and hence knowledge is more of a social and cultural experience. Here, students look at real world problems and situations where this knowledge can be applied and develop the techniques or processes to solve them. Based on Vygotsky's ZPD (1978), students are in a position to find solutions to problems that they would not have been able to on their own. But now that they have the support of their peers (and if necessary, the teacher) they are able to solve problems that are outside their level of actual development and understanding.

Figure 39: Concord Tower

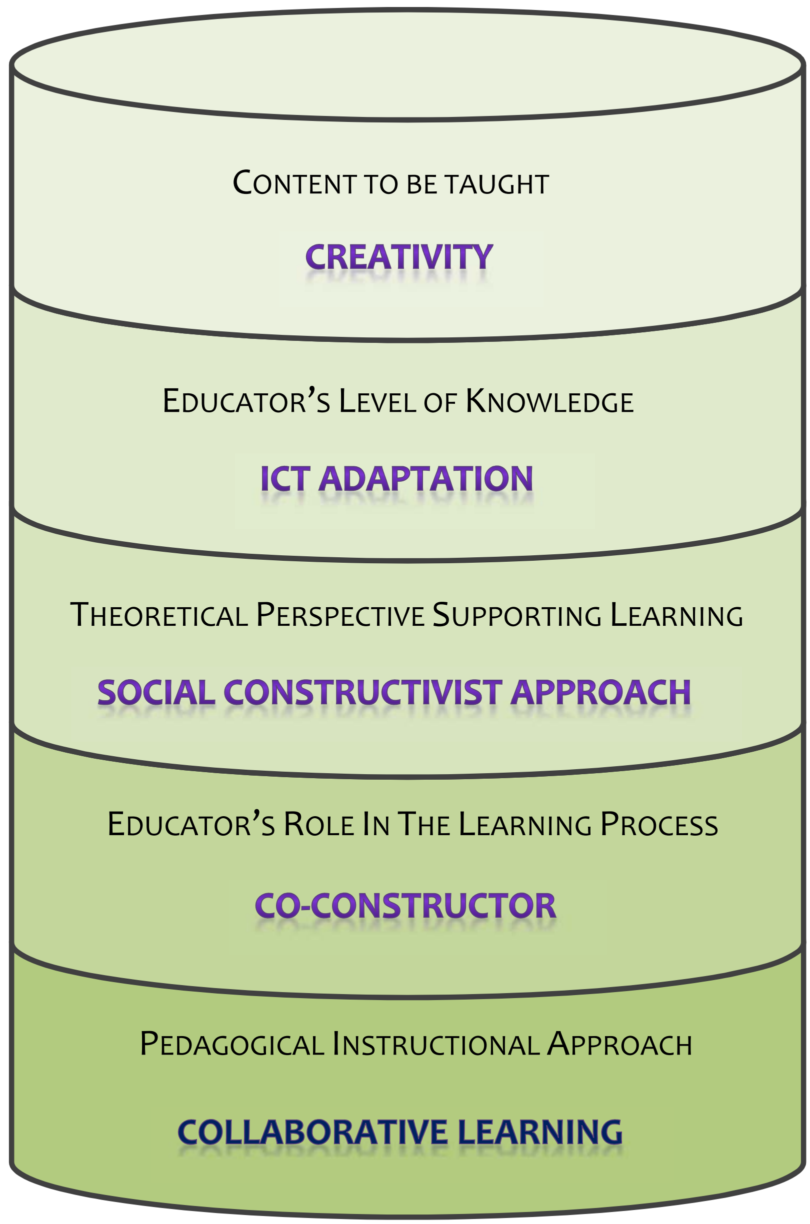
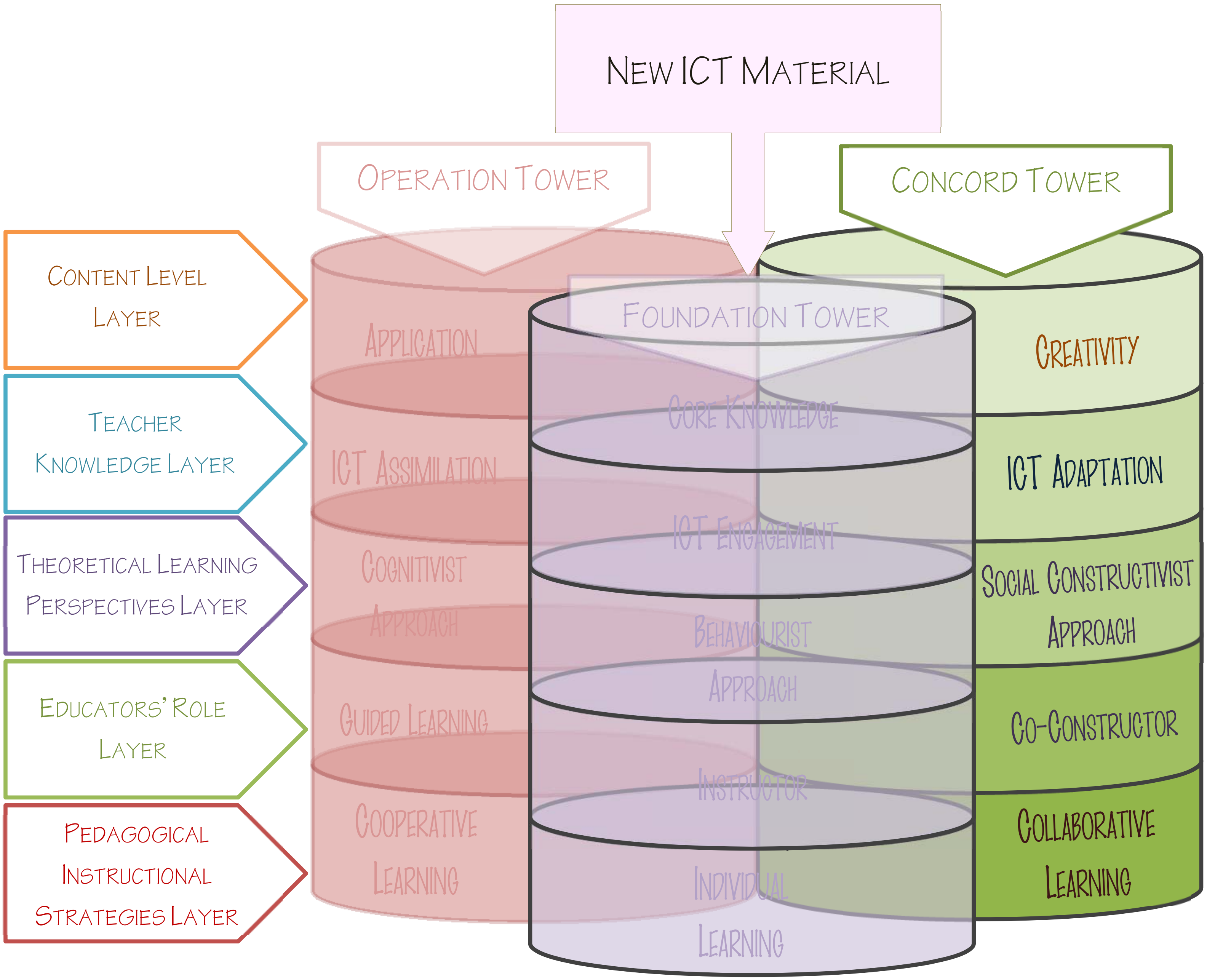


Figure 40: Concord Tower as part of the Model



What role should I (educator) play in the learning process?

Co-constructor. The teacher's role transitions to that of a collaborator when using the lens of a social-constructivist approach. At this stage, the teacher takes on the role of a peer and stimulates the process of interaction and discussion. In turn, students now have a good grasp of the foundational knowledge and its problem solving capabilities and can look to solving applied real situations. While collaborating, students discuss and share their understanding and a collective solution is constructed to solve the problem. So now students are developing a greater understanding of the employability of the ICT but they need the support of their peers and/or adult guidance to successfully achieve their goals.

When faced with an environment having limited availability of ICT equipment, the teacher can present the ICT environment to a group of students with access to one machine and a problem where the students can collaborate and the teacher can join in the process as a knowledgeable peer.

What pedagogical instructional approach should I take?

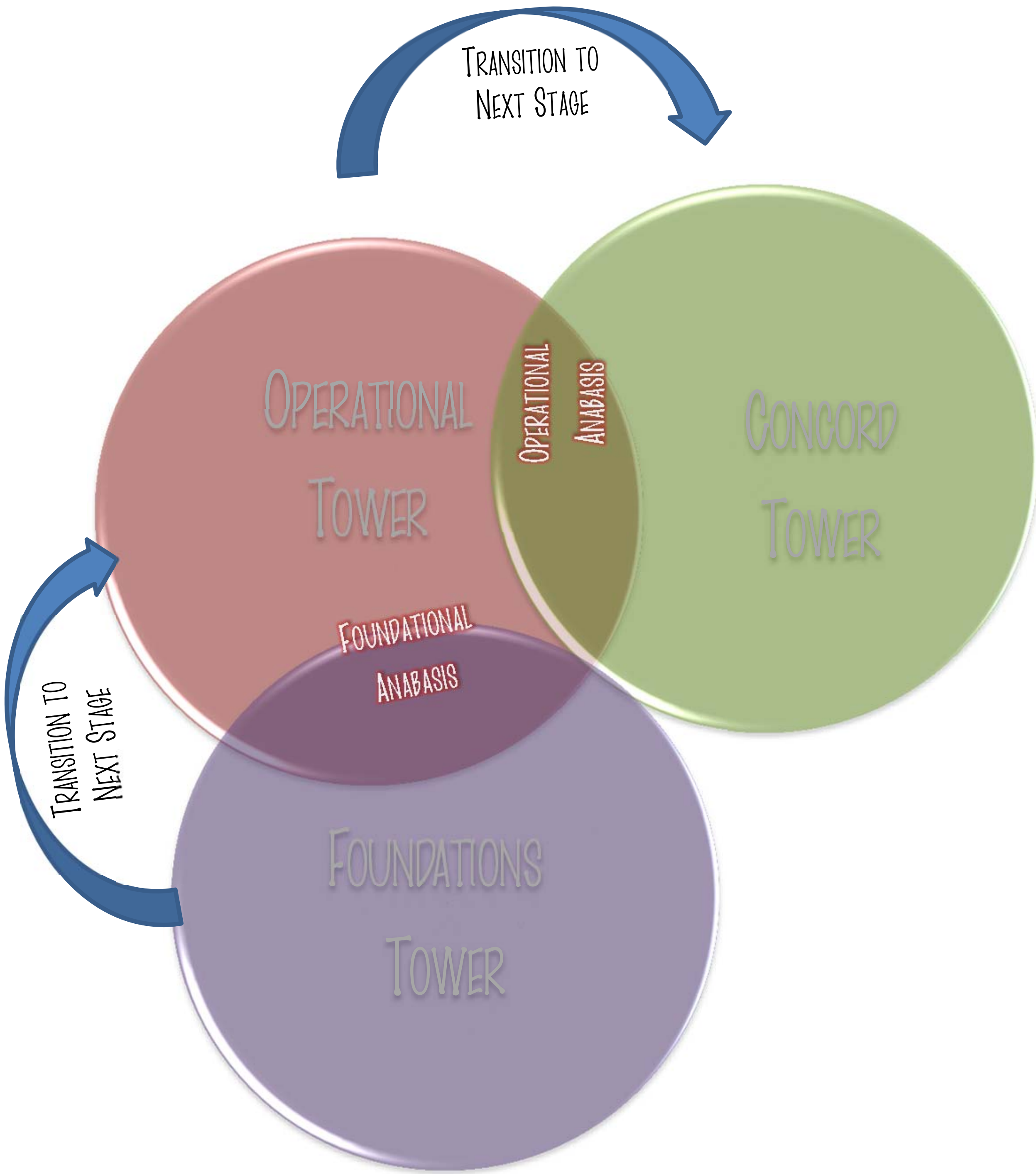
Collaborative learning. The teacher takes the role of a peer and stimulates the process of interaction and discussion by being a collaborator. The pedagogical strategy is splitting students into groups that are given a task and the group takes on the full ownership of the task. The teacher however always remains on hand to support or advise, ask questions and guide the process. Here the social-constructivist approach is best suited. The students are now at a stage where they have a good grasp of the foundational knowledge and its problem solving capabilities. According to Baumgartner (2004),

> teachers no longer control learning situations completely. They must enter into situations with undetermined outcomes, mastering situations they encounter. The only difference between teachers and learners is that of experience and meta-knowledge, where teachers are more capable of reflecting on complex situations (p.4).

The collaborative learning pedagogical strategy is well suited for classrooms with limited ICT equipment, since the emphasis in this strategy is on group dynamics, discussion, collaboration and teamwork. So the ICT becomes a shared resource and the focus becomes the ideas and new knowledge generation.

Foundational Anabasis and Operational Anabasis. The foundational anabasis and the operational anabasis are the transition state between the Foundation and Operational Tower and between the Operational and the Concord Tower respectively. These transition states are represented visually in Figure 41. Each of the five layers in the towers has these transitional stages. The term ***'anabasis'*** was chosen since it means - going upwards (from Greek, 'anabainein', ana- 'up' and bainein 'go'– Source http://oxforddictionaries.com/definition/english /anabasis). In the model, the movement from one stage to the other via the transition area happens when the student/teacher has acquired a basic understanding of the stage they are in and are now moving to the next higher skill level (going upwards).

Figure 41: Foundational and Operational Anabasis



Since it is not possible for a teacher or a student to jump straight from one stage to another, these transition stages were found to be necessary in the model. As we progress from one learning situation from another, we transition through a stage in the middle where our knowledge is not yet complete from the previous stage. Rather, we are in the position to apply the skills and knowledge we have acquired to test the next stage and this position is where our anabasis stages find themselves firmly rooted. These stages present themselves as overlapping stages between two components within a layer and represent the relationship between the two components as well as the progress from one component to the other.

Validating the Model

The Judgment by Experts technique was used for validating the model. To provide a balanced review, I used two expert groups of researchers and practitioners so that the validation is not one sided and is "reflecting the 'collective wisdom' of the field rather than the views of a single person or group" (Moody, 2005, p. 258). The two groups of experts were university instructors (who are experts in the theories of education, educational research and teacher training) and education practitioners (who are experts involved in the teaching and scaffolding of learning) both were chosen based on their background of research and applied knowledge of the field.

For this assessment, two faculty members from education departments at Canadian universities as well as two teachers from a Maritime school system were requested to participate in the process of validation. As part of the process of selecting the teachers, it was a requirement that their class had more than 4 students per computer. This criterion was based on the current research suggestions by Corbett and Wilms (2002), who recommended that ratios better that one computer per four or five students are necessary to ensure significant improvements in learning. However, for essential practices to be fundamentally changed, DiSessa (2000) suggested that the critical ratio is one computer per three students. The requirement of more than 4 students per computer satisfied the issue of limited ICT environments.

The expert responses were collected based on the following questions:

a) Is the model clearly presented/easy to understand?
b) Does the model provide teachers/instructors with insights and ideas that they might otherwise overlook?
c) Is the model easy to use?
d) Is the model comprehensive? Does it address key dimensions of instruction?
e) Would the model help teachers/instructors engage students more fully in the learning process?
f) Is the model flexible? That is, can it be readily adapted to suit changing circumstances?

Since the experts were chosen from two different backgrounds (theoretical and practitioner), the effort was to validate the model using both these perspectives. The responses collected were summarised and grouped.

Is the model clearly presented/easy to understand? The feedback received was positive. One of the school teachers commented that: “Yes, it’s clearly presented and is straight forward. It goes step by step which seems easy to apply”. It was also noted that “The language is friendly. The illustrations are concise and the steps seem attainable or easily mastered”. It is imperative that teachers who are presented with the model understand it since they are the first line of users for whom this model was developed. If there is any ambiguity in the presentation, then it could lead to the model being either used improperly or even rejected by its core audience.

The teachers’ feedback was resonated by one of the professors who noted that: “I thought that your model was clearly presented and could be readily understood. You avoided using unnecessary jargon in your descriptions and I believe that the language used would be readily understood by educators. That is, educators could relate your descriptions to classroom situations.”

This first question was based on the need to find out if the model was easily understood, since all of the following questions are based on a complete understanding of the model. It is very difficult to critique something that you do not fully understand. In addition, a clear presentation aids understanding the idea and its potential.

Does the model provide teachers/instructors with insights and ideas that they might otherwise overlook? Teachers deal with varied environments in terms of support, infrastructure and training. It was important that the model provided the educator support in their implementation of ICT. However, it was also important to address the following question: Could the model provide insights that could help the educator perceive the issue of ICT integration differently? One of the professors noted that:

> Your model outlines ways to connect theory to practice. This feature makes an important contribution to technology instruction because educators do not always make these connections on their own. For example, I recall teaching some pre-service and in-service educators who did not automatically make the connection between the pedagogical strategies that they already used in everyday instruction and those used with technology instruction. Perhaps, they initially perceived technology instruction as a novel situation that required novel instructional approaches. Your model focuses explicitly on these connections.

She further elaborated that:

> Although educators study learning theories in their per-service and in-service education courses, they do not always apply these theories. Some think of theory as operating in a different realm from practice, expressed in phrases such as: “well, that might work well in theory”. Theories only become useful when educators use them routinely to plan, analyze or reflect upon instruction. Your model encourages educators to use theories in their work. Your descriptions of the learning theories were clear and easy to understand.
>
> I appreciated your pragmatic approach to application of learning theories. Learning theories courses often encourage the use of one theory to the exclusion of all others. In contrast, you portrayed the usefulness of each theory for addressing

> different instructional situations. There are cases in technology instruction where educators use one theory exclusively such as repeated drill and practice with limited application. In such situations, students often fail to realize the relevance of what they are using and find this instruction tedious rather than motivating.

The feedback from one of the teachers was similarly encouraging and noted that:

> Yes, because we look at this and then when we follow our curriculum this helps us with what we are doing and see things differently. If you are doing a concept with computers it allows more leeway in the child interacting with new ideas. When children use computers and they work individually or in groups, they come back with more answers and more perspectives since there are more ways of doing things.

Is the model easy to use? Usability is another one of the key factor that is core to the model design, since an easy-to-use model means that the design works and helps educators by providing some type of support. One of the professors commented that:

> I believe that the ease of use would depend on an educator's prior experience. There might be a steep learning curve for those who integrate technology into instruction infrequently but less so for those who use technology on a regular basis. However, for infrequent users, your ideas are laid out in a clear, straightforward manner and that might motivate the adoption of your ideas.

She further noted that:

> The overall process that you describe is a dynamic one. You describe each vertical facet and related horizontal layer in a sequential manner (appropriate in my view). I do not believe that it was your intention but some might perceive that you are outlining a linear or sequential process instead of a parallel/simultaneous process.

This feedback did make me realise that when the model was presented to some educators, it could cause the user to misunderstand the design as sequential and not dynamic. To clarify this design feature, appropriate changes were made to the portion where the model design was introduced. Fortunately for the two teachers used in validating the model, this was not an issue. One of the teachers noted that: "Yes, because looking at the model it tells me what steps are there and explains them. Once you get the idea and how the model works, it's brief and easy to understand."

Is the model comprehensive? Does it address key dimensions of instruction? All of the experts responded positively to the comprehensiveness of the model and confirmed that it covered the key aspects of ICT integration in the classroom. The in-depth presentation and discussion however, did seem to overwhelm every expert. One of the teachers in her feedback said: "Before I could grasp an understanding of it - I had to re-read it a couple of times!" However after that initial obstacle, her response was that: "it's (the model) clearly presented and is straight forward". In the same vein, one of the university instructors identified the comprehensiveness both as a weakness and strength.

Her response was similar to that of the teacher where she suggested that "the model is so comprehensive that it can be overwhelming at times. Use of parallel construction in your description of the layers was appropriate but there are so many steps that educators might get bogged down trying to keep track of all these steps". The other teacher also was overwhelmed at first but her response after getting a grasp of the model was that "I can see some aspects of ICT integration that I had not considered while teaching".

The problem is that very few people are aware of the complexity involved in the teaching and learning process. Added to this complexity is the integration of ICT which on its own is an extremely complex process having many layers in integration, as well as compatibility and operational issues, many of which have been discussed as part of the literature review. The university instructor commented on the strength of the comprehensiveness as follows: "It is good to portray the complexity of the instructional process for non-educators and educators alike. Non-educators might not realize how complex instruction is and underestimate the challenges that educators face. In contrast, educators often take these processes for granted and it may be helpful to revisit them in a more formalized way."

The model has attempted to provide the educator with a roadmap in ICT integration in the classroom. An effort has been made to include several aspects of ICT integration that were identified as issues in various research studies from the field. The model does not claim to be all encompassing but it does make a concerted attempt to address prominent issues. The response from the experts did confirm that the model has integrated and addressed issues that are currently faced by educators.

Would the model help teachers/instructors engage students more fully in the learning process? The advantage expected by using this model is that there is an element of support provided to the educator no matter what level they are at in their integration of ICT. This advantage is expected to help the educator increase their level of confidence when approaching the integration of ICT.

One of the professors commented that:

> You provided helpful, realistic guidance for educators planning technology instruction. Your focus on limited access to computers or access to dated technology was realistic based on your findings in the literature that this situation exists in many classrooms. You offered good ideas for instruction that would benefit student learning regardless of the number or status of the available technology. That might encourage educators to increase their use of instructional technology.

She further elaborated that:

> It was good that you conveyed the idea that students do not need to master technical skills before they can move onto simple applications. The continuous cycling from technical skills instruction to application is good from two perspectives: 1) the relevance of the skill being taught is apparent and 2) the student's memory is not overloaded. I used to refer to this situation as learning on a "need to know basis". I attended many technology workshops that attempted to

> be "all things to all people" (i.e., ideas were offered for all levels of expertise at the same time). By the time I needed to use more advanced applications, I would have completely forgotten the associated skill. No paper copy of the skills or applications was provided to refer to at a later date.

This feedback was really important since it confirmed the fact that if the process of ICT integration is broken down into smaller parts along with association with other relevant features (theoretical reasoning, type of role to be played and so on) the process can really be enriched and can help support the educator in their task.

From a practitioner's perspective, one of the school teachers suggested that:

> For my grade level of six and seven year olds individual learning would be more helpful as they need a teacher to help them go through the steps. For some younger teachers who are tech savvy, ICT integration is easier but the model would allow for perhaps more interaction between the younger and older teachers to learn from each other as well and that might be helpful. There are websites that allow you to engage in language, art or writing skills on the website but these often need additional add-ons which cost and right now our school doesn't have funding for that. A portion of the software used by the teachers in the classrooms for teaching is paid for by the teachers themselves and this is not refunded by the school.

A number of interesting observations are there in this feedback. The teacher commented on engaging not only the students but also using the model as a learning tool between the younger (assumed more tech-savvy) and older colleagues. This feature was not thought of when the model was designed. However it expresses a level of versatility and adaptation that can be seen when a user understands the model and then seeks to make it his/her own. Also of importance is the observable frustration of this teacher who would like to do more by just accessing educational websites for the usage of the class but has to pay for this facility personally. This sentiment I have found repeated on a number of occasions where teachers have to sacrifice a certain amount from their paycheque each month if they are to follow the educational guidelines suggested and provide their class with adequate opportunities in learning with ICT. Although not part of the model, these statements add to the information found in the literature review about why teachers are hesitant in integrating ICT in their classroom.

Is the model flexible? That is, can it be readily adapted to suit changing circumstances? It was imperative that the model was flexible since every teacher has to deal with different school environments and levels of ICT integration. One of the school teachers said: “Yes, I can see the model is flexible. The way it is presented allows the teachers to include it into their instruction and modify it to any grade level”. The other teacher noted that:

> You just need to know the topic you will be teaching and then apply it to that format. It can be adapted to changing circumstances because if there is any upgrade, it allows the flexibility to adapt. As a teacher for grade 2, it allows me to

> include changes. For children it allows learning by adapting to their needs and the level they are at in their instruction. This allows the child to meet with success.

Educators are frequently faced with challenges and need to adapt to these changing circumstances in order to ensure that they are able to perform their duties and impart a quality education. When the model was designed, the iterative cycle of modifications had ‘flexibility’ as a key aspect that was held as crucial to the design. The reasoning was that any model developed would be of very limited utility to the educator if they were not able to connect it with their situation.

One of the professors commented that:

> The model is flexible and was designed specifically to adapt to different needs of students with different levels of familiarity or expertise with the technology being used. A range of possibilities is offered within each horizontal layer and its overlapping areas. This feature is important in increasingly diverse contemporary classrooms because it allows educators to individualize instruction.

This sentiment was echoed by the other professor who also found the model to be flexible and noted that “the model once understood allows educators to adapt it according to their needs and to that of the classroom”.

CHAPTER 5

SUMMARY, DISCUSSION AND RECOMMENDATIONS

This research study focused on developing a model for teachers to help them integrate ICT in their classrooms. The goal was to assess how integration of ICT in the classroom could be best accomplished. This goal was achieved by assessing how ICT was currently integrated in schools, exploring the hindrances that teachers faced when trying to integrate the technology in their teaching practice and considering the solutions to these hindrances developed in various environments. Not only were issues faced by educators identified but models developed for similar situations in other areas were also examined. This background information was used to help develop an applicable model for use by teachers to help them in integrating ICT in their practice.

This chapter will summarize key pieces of the literature and then describe the synthesis of these ideas to design the model and its components. Finally, a discussion of the implications of this study and recommendations for further research in the optimal integration of ICT in the classroom will be presented.

The Current status of ICT in Schools

To integrate ICT into their curriculum, significant time and money is allocated by schools feeling pressured to do so. The prime intent for this investment is to improve student academic achievement (OECD, 2001; Plante & Beattie, 2004; U.S. Department of Education, 2000). However, existing trends of increasing financial limitations and projected economic conditions make it challenging for a large number of educational establishments to provide this technology effectively to their students (Ali, 2007; Zhao et al., 2002). The two issues that are of prime importance at this juncture are that technology (hardware, software and peripherals) costs money and secondly, the rate at which technology becomes obsolete by becoming advanced is phenomenal. So, with technology evolving and rapidly becoming obsolete, for schools, there is an emergent gap between the integration of advanced technology and teaching and learning.

Teachers are fundamental to this ICT integration plan, since they are the key stakeholders who deliver or co-construct the knowledge to or within the classroom. To successfully perform this integration, they have been under pressure to learn technology skills and then teach by incorporating ICT into their practice. For teachers, it becomes an uphill task to integrate this ongoing innovation into the classroom, which in turn affects students.

Another issue that was highlighted was that the Personal Computer (PC) is a single user machine and has not been designed for the use of more than one user. However, this has not been the case since the introduction of microcomputers in schools, and even today many schools, allocate a single PC to multiple users. Research conducted by Korte and Hüsing (2007) where they surveyed 27 European countries, showed that in schools in Europe, the average ratio is one computer per every 9 students, while in Canada, the school median is 5 students per computer (Statistics Canada, 2005). However, DiSessa (2000) suggested that the critical ratio is one computer per three students, for essential practices to be fundamentally changed. According to the US National Teachers Survey (2005), only 13% of teachers had one computer to two or three students in their classroom.

Based on the research, with many schools having to deal with some form of group/shared learning using ICT, it became important to look into this issue and find the ideal techniques used to address teaching and learning in this format. In the model proposed, this has been incorporated in the form of a pedagogical instructional strategies layer, addressing learning group instruction.

The literature analysis of the current status of ICT in schools provided us with vital information regarding the position of schools. Schools need to play a balancing act with regards to acquisition of ICT and significant pressures are faced by them when attempting to constantly deliver a leading edge ICT integrated education.

The literature review then examined the impact this technological innovation has on the schools.

Impact of Innovation on Schools Integration of ICT

Technology frequently gets obsolete owing to innovation. However, there are other factors that also play a part in the rapidly evolving landscape of ICT and its implementation. One of the factors identified was the idea of ‘planned obsolescence’ where products are purposely designed to have a limited shelf life and are quickly replaced by their successors. Another factor was the inherent symbiotic relationship between software and hardware where enhancements in one triggers the other to become obsolete. Aronson (2008) suggested that there is already the successor (or replacement) getting ready to roll out of the manufacturing plant by the time many of us get our hands on the state-of-the-art piece of technology.

Hence the major concern with adopting new technology in schools is that it puts a persistent strain on the limited budgets and dwindling resources often leaving a significant number of schools with either obsolete technology or a high computer to student ratio for new technology. About 72 computers per school were used for educational purposes according to the report published by Plante and Ertl (2004). With a median of 12 minutes per school computer dedicated to support and maintenance each month, the number of working PC's for use available at one time for teaching drops below the average of 72 computers per school.

The report *'Integrating ICTs into education'* by UNESCO (2004) stated that it is complicated and costly to integrate ICT in schools. Since there are a number of key factors like the right equipment, trained staff, appropriate technical support and proper training, all of which need to be working in harmony to ensure proper integration (p.7).

The review of the literature highlighted some key issues with regards to the impact innovation has on the integration of ICT in the classroom. The cost of technology, the complexity of the integration process as well as the rapid launch of newer products all have had a detrimental impact on the successful integration of ICT in schools. The impact is not just having fewer machines per school; it goes deeper. That is, the integration of ICT requires that the technology be in sync with the different components (software, hardware, support and staff) which directly affect the quality of teaching and learning.

External Factors that Contribute as Barriers to the Integration of ICT

Technology integration is not just about the availability of hardware and software in the classroom. It also encompasses the costs associated with supporting the ICT with software and hardware updates and crashes, compatibility issues between older hardware and newer software (and vice versa), errors and issues in integrating various types of peripheral equipment like scanners, overhead projectors, printers and so on. So the impact of the innovation is not limited to just the purchase of new hardware and software but this issue was found to have a deeper impact with many layers (cost, time, resources and support), each adding to the complexity of the impact innovation has on the integration of ICT in schools.

Fabry and Higgs (1997) noted that the suitable amount and appropriate technology along with adequate access is crucial for effective integration of computers and that proper use of the technology is not assured by simply having the right numbers of computers. This sentiment was also emphasized by Becta (2004) who reported that low quality hardware, inappropriate software, improper organisation of resources, or lack of access, each can impact the ICT usage in schools.

The literature review highlighted various concerns on the integration of ICT in the classrooms. First, it was noted that model ICT implementation occurs when various elements (hardware, software, technical support and so on) each having a complex relationship with the other function as one. Second it was also noted that having the ICT with inadequate access and an unorganised setup is equally disadvantageous to the integration of ICT in the classroom.

The current status of ICT integration by teachers in their practice

Teachers are the key stakeholders in the integration of ICT in the classroom. They learn, understand and work with the various technologies that are part of the ICT and then impart that knowledge to the students as part of the curriculum. The US National Teacher Survey (2005) indicated that just about 25 % felt that their training was adequate enough to use recent instructional software packages and only about 54% teachers incorporated computers into daily instruction. Also of importance was the finding that just 21% of teachers thought that they had had suitable professional development training in the use of assessment software.

The literature review on the current status of ICT integration by teachers in their practice provided information that was the foundational stone in the model development. Identifying through research that teachers were not freely integrating ICT in their practice, the answer to the question "why?" became of prime importance. Knowing the issues that hindered teachers from integrating ICT in their practice helped me look for answers to those issues and identify solutions. The understanding was that answers to the reasons behind this discomfort of freely integrating ICT in teaching and learning would provide the basis for the model design. The solutions were searched for in a multi-disciplinary environment (in areas like computer science, education, cognitive science, psychology and so on) and similar solutions to issues faced in those fields that had similar structures were identified. Two layers were proposed in the model (content level layer and teacher knowledge layer) that address some of the hindrances faced by the teachers and possible ways to address them. The entire model is also supported by the integration and cross-validation with relevant learning theories.

Issues that hinder teachers from integrating ICT in their practice

Research shows that in a significant number of schools the prospective of learning with ICT is lost, as several educators still have gaps in their ICT knowledge. These gaps prevent the integration of ICT in the classroom, despite the apparent benefits of the use of ICT for educational purposes (Bingimlas 2009; Pelgrum 2001; UNESCO 2004).

Pelgrum (2001) identified a lack of knowledge and/or skill as well as issues with ICT integration into the lesson, as the top non-material hindrances to developing a successful ICT school environment. Recent research into the barriers to ICT integration in schools also highlights that teacher attitude plays an important role. Being strongly influenced by the support and scaffolding available to the teacher (in terms of implementing the ICT), a teacher’s attitude is not just a personal dynamic. Another key issue identified was training. It was noted that even in situations where the teacher may have had a formal training in instructional technology; there was a very high probability that they had little to no understanding on how to transform that training into their teaching practice and curriculum design (Bauer, 2000; Hardy, 2003).

Summarising the literature review by various experts in the field, a number of hindrances were identified. However, when looked at closely, the principal factor that was frequently emphasized was (lack of) knowledge/skill. This factor impacted most of the other factors that were identified as hindrances: lack of knowledge and skills caused some teachers to - fear loss of control (Hodas, 1993), lack of confidence in utilizing ICT tools (Tella et al. 2007), inability to translate training into their teaching practice and curriculum design (Bauer, 2000; Hardy, 2003), inability to connect pre-service training to classroom application owing to variations in learning the material and teaching it (Oren, Mioduser, and Nachmias, 2002).

The other key factor highlighted was equipment. Awan (2012) echoed the research by Haydn and Barton (2006) and noted that factors such as access to equipment, training, and the support of the education community, played a huge part in the attitude the teacher had and their inclination to integrate the ICT in their practice (p.258).

Keeping these concerns in mind when it comes to developing learning environments, it was realized that the focus needed to be shifted from developing technology intensive classrooms. For instance, although there are potential benefits of using the latest ICT in teaching and learning, one should bear in mind that the value of knowledge that can be imparted and gained on its own with limited use of technology is valuable. The President's Panel on Educational Technology (1997) reiterated this sentiment by suggesting that lessons using ICT should not focus on the capability of the hardware; they should highlight the content and pedagogy (p.8). The focus then in the implementation of ICT shifts from the state and capability of the technology to what advances in comprehension can be achieved by the students during learning.

These ideas formed the basis of the 'teacher's knowledge layer' (in the horizontal cross-section). In this layer, the method suggested by Shaw (1992) used for teaching software development was adapted. The layer focuses on the main functions and principles of ICT integration by gradually phasing in both training and knowledge building.

Impact of Group Instruction on Learning with ICT

Research has established that a great number of schools do not have a one computer per student ratio (Corbett & Wilms, 2002; DiSessa, 2000; Korte & Hüsing, 2007; Pelgrum, 2001; Statistics Canada, 2005; United States National Teachers Survey, 2005) and hence some form of group instruction and group work has to be integrated as part of the teaching practice. So instead of seeing this working in groups as a negative influence and focusing on improving the student-computer ratios, a different approach was taken. Since it was a challenge for schools to continually fund more and better technology, the focus was shifted to identifying how group working and instruction could be best designed using the current ICT setup available. When working with college students, Schoenfeld (1989) emphasised the benefits of problem solving in small groups.

He suggested that a rational deliberation of issues and vigorous discussions was stimulated during group work. He claimed that this deliberation brought groups closer in their learning.

The model developed incorporated group learning in the horizontal cross-section as the ‘pedagogical instructional strategies layer’. This layer was designed by adapting the three mode model for teaching and learning in e-learning environments proposed by Baumgartner (2004). The three modes suggested cover – Individual learning (To transfer knowledge), Cooperative learning (To acquire, compile, gather knowledge) and Collaborative learning (To develop, to invent, to construct knowledge). Based on what level of content the teacher was trying to impart, the focus was on understanding the content, developing a solution and then working on the PC to achieve the outcome.

How might educators develop group instruction to optimize student learning?

Group learning involves active learning. When students get enthusiastically involved in the learning process, the result is usually a deeper understanding of the subject matter. As we progress in life, peer interaction supports our knowledge increase. Research in the field shows us that, in appropriate settings, group intelligence supersedes the smartest people in the group (Surowiecki, 2004, p.xiii). Collaboration as part of learning in children is supported by both Piaget and Vygotsky (Berk & Winsler, 1995; Whitmore & Goodman, 1995).

The role of teachers is to assist learning and to make sure that they play their appropriate part in promoting the application of proper learning strategies. Associating the teachers' role with the appropriate theoretical learning framework and what needs to be taught provides teachers with a grounded reasoning with clear associations for the role they could play.

The model developed incorporated this role in the horizontal cross-section as the 'educators' role layer'. This layer presented three roles that the educator could play while assisting learning - Instructor, Guided Learning and Co-constructor. The three roles cover the stages of when the initial core-knowledge that needs to be understood is imparted through instruction. Then gradually, the educator starts moving to a more supportive role as a guide and a co-constructor. In these roles, the focus of the educator is to gradually allow the student to develop their understanding and grow more independent in their problem solving while being supported at each step of the process. During these two stages, the students collaborate and cooperate with other students while developing their own knowledge and also interacting with the technology.

Contribution of Learning Theories to the Integration of ICT in Education

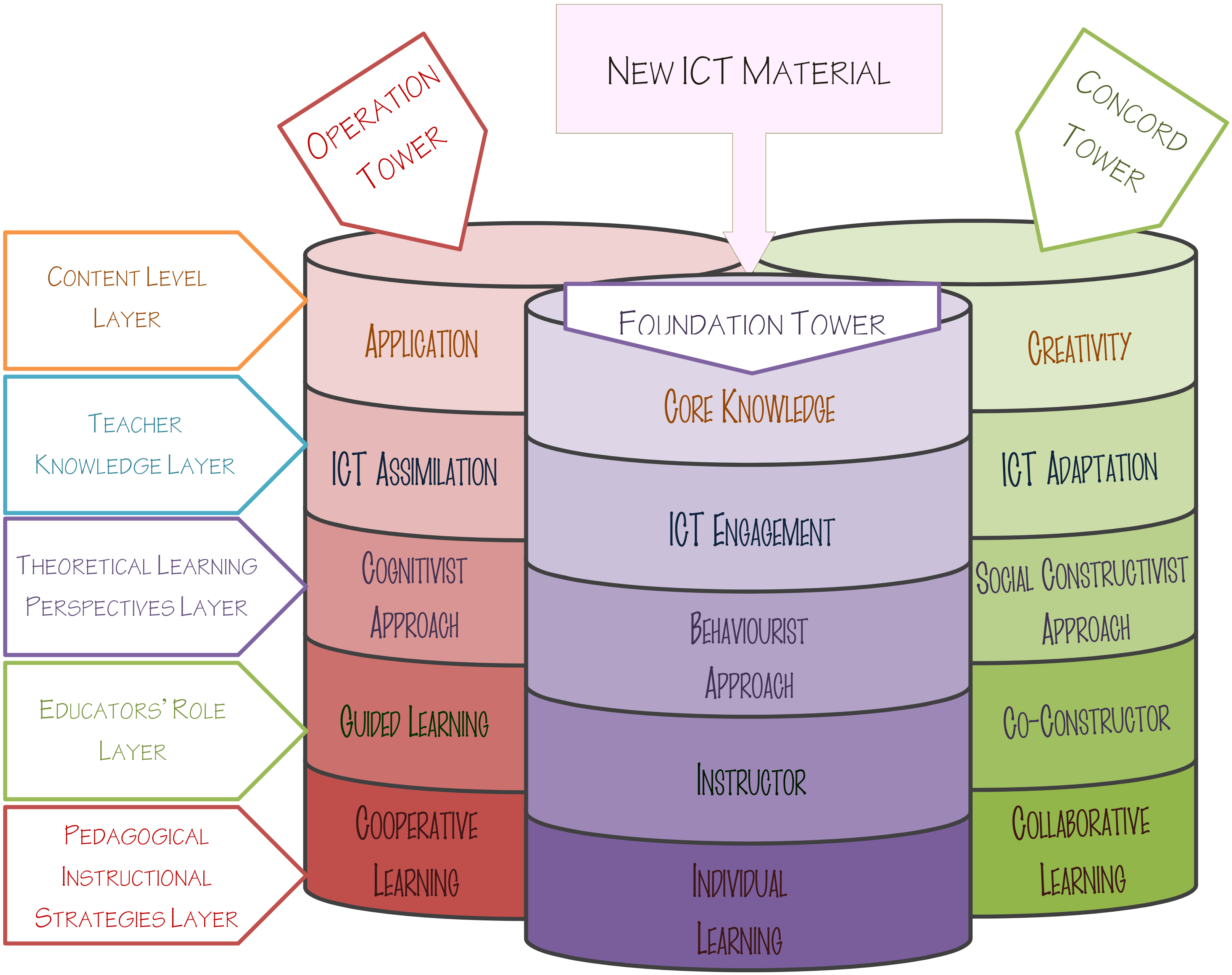
For teachers, familiarity with learning theories does not necessarily generate connections automatically between different aspects of teaching and learning. Ormrod (2012) suggested that to assist the full potential of learning, theories are of immense value in developing pedagogical strategies and learning environments (p.9). Kridel (2010) suggested that the three main philosophical frameworks encompassing learning theories are: Behaviourism, Cognitivism and Constructivism.

Based on learning theories, the model presented restricts the scope of the three learning theories to selected aspects and their applicability in the ICT classroom environment. The model developed incorporated this in the horizontal cross-section as the ‘theoretical learning perspectives layer’. This layer presented the three theories as the – Behaviourist approach, Cognitivist approach and the Social-constructivist approach. The behaviourist approach was seen as more suitable for introducing and imparting core knowledge but when the student started to connect that core knowledge to solving tasks, a more cognitivist view was seen as more appropriate. The social-constructivist approach provided the backbone for addressing real-world problems. In this learning environment, new and richer learning experiences are gained by sharing and co-constructing knowledge both with the teacher and other students.

The Model

The model was designed from the issues raised in the literature review. The three vertical towers addressed the knowledge state of the individual. The towers covered the foundational, operational and constructional aspects of knowledge acquisition. A visual overview of the model is presented in Figure 42. The foundation tower represents the first level knowledge acquired when learning new material. The operational tower represents the next level of knowledge acquired when the foundational knowledge that was learned can be applied to solve tasks presented. The concord tower represents the knowledge

Figure 42: Overview of the Model



acquired by finding solutions to real-world problems by being creative and in collaboration with peers.

The five horizontal layers address - what needs to be taught (content level layer), the level of knowledge the educator needs to have at each stage (teacher knowledge layer), the theoretical perspective that supports learning in shared ICT environments (theoretical learning perspectives layer), role the educator could play in the learning process (educators' role layer) and the pedagogical instructional approach that could be taken to help learning (pedagogical instructional strategies layer). The design of the model is dynamic and not sequential, so based on the educators' needs or preferences, the sequence of the layers can be re-arranged.

There is a significant relationship and a strong connectivity between the various elements in both the vertical and the horizontal layers. For the educator, the model shows the connection between various areas of ICT implementation in the classroom. This connection can be seen for example in the form of the relationship between the learning theories, the educators' role and the content to be delivered when introducing new material.

The attempt made by this model is to provide the teacher/educator with a template showing the relationship between various layers and knowledge stages. The hope is that when teachers need to teach a new material to the class that requires the integration of

ICT, this model will help them identify some of the relevant issues and support their implementation.

Broader implication of the research

The model was designed to help support teacher ICT integration in K-12 schools. However the model could be used as-is or adapted for use in rural communities and developing countries where ICT is scarce and the student-computer ratio is much higher. For example in Kenya, access to ICT at the primary school level is at the ratio of 1:250 (Ministry of Education, Kenya, 2006). Other suggested environments where the model could provide support to teachers are areas hit by natural or social disasters as well as politically and economically deprived areas. Since in such environments, it sometimes takes years before a new infrastructure is put in place. For example Haiti was struck by an earthquake in Jan 2010 where 3,978 schools were either damaged or destroyed. (http://www.haitispecialenvoy.org/relief-and-recovery/key-statistics/). Almost three years later, although many of the schools have been rebuilt, there is still a lot of work to be done to return to the pre-earthquake levels.

Discussion of the research limitations

The model developed as part of this thesis is hypothetical. Even though I have attempted to validate it using both researchers and practitioners, there are limitations due to time and scope of the thesis. First, the sample size of our experts is very small, so it is possible that the sample may not be representative of the expert opinion on the matter. Second, although the model was built on significant research in the field, it has not been piloted or tested in the real world. By piloting the model, it is possible that the feedback may confirm the robustness of the model or the need to modify elements of it. Third, it would have been of immense benefit if I was able to interview teachers and school boards, so that I could incorporate their input into the model along with the literature in the field.

Suggestions for further research and improvements

To address the limitations of the current study, it would be prudent to validate the model with a broader range of experts from the field and practitioners who have an interest in integrating technology in their instruction.

The next stage would be to survey teachers and school administrators for feedback on their usage of ICT and to identify possible areas that may not have been covered by the model. A survey to receive feedback from the teachers was designed as part of this research and is attached in Appendix 1. Also, due thought was put into the possible future piloting and testing of the model. For this eventuality, a detailed exploration of the ethical considerations of working in a classroom with teachers and children was developed and is attached in Appendix 2.

To pilot the model, it would be suitable to recruit a small group of interested practitioners to use it when planning for instruction using ICT. Interviews could be conducted with these practitioners about their experiences with the model at different points in a term.

To improve the model, a deeper analysis of the learning theories, issues and limitations faced by the teachers should be conducted. It would be important to compare teacher views about appropriate learning theories to use for different stages of instruction to the views recommended by the model. Also, to what extent do teacher perceptions of key issues and limitations align or differ from those presented in the literature?

Feedback from students learning with ICT should also be sought. Student perspectives are often overlooked in the research and this gap is important to address. Most frequently, current research focuses on student achievement as measured by a standardized test. This focus provides a limited view of the overall learning experience.

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APPENDICES

Appendix 1

Survey Assessing Computer Usage in Classroom

1	Within which school area you are employed?	☐ HRM	☐ County Neighbouring HRM	
		☐ Other Parts of NS	☐ Outside NS within Atlantic Canada	
2	Do you teach school as your main source of employment?	☐ Yes	☐ No	
3	What grade do you teach?	☐ Elementary		
		☐ Junior High	☐ Combination of Elementary and Junior High	
		☐ Senior High	☐ Combination of Junior High and Senior High	
4	What is your approximate class size?	☐ Less than 10	☐ 10-15	☐ 15-20
		☐ 20-25	☐ 25-30	☐ More than 30
5	Do you have sole access to a Personal Computer(PC)(Desktop,Laptop, Tablet or Other) ?	☐ Yes	☐ No	
6	Do you use a PC as part of your everyday class preparation?	☐ Yes	☐ No	☐ Sometimes

7	Do you have access to PCs in your classroom?	☐ Yes	☐ No	If 'No' Answer Q10, Q14,15,19 and Q20
8	How many working PCs do you have in your class?	☐ 1-3	☐ 4-6	☐ 7-9
		☐ 10-12	☐ 13-15	☐ More than 15
9	Do you use PCs in your classroom teaching?	☐ Yes	☐ No	
10	How many years of experience do you have with using PCs in teaching?	☐ No Experience	☐ Less than 1	☐ 1-3 Years
		☐ 3-5 Years	☐ 5-10 Years	☐ More than 10 Years
11	Do you have any formal training in the usage of PCs?	☐ Yes	☐ No	

12 Please select the courses and frequency you use the available PCs to teach :

Course				
☐ Language	○ Always	○ Often	○ Rarely	○ Never
☐ Maths	○ Always	○ Often	○ Rarely	○ Never
☐ Science	○ Always	○ Often	○ Rarely	○ Never
☐ Social Studies	○ Always	○ Often	○ Rarely	○ Never
☐ History & Geography	○ Always	○ Often	○ Rarely	○ Never
☐ Art	○ Always	○ Often	○ Rarely	○ Never
☐ Other - (Please Specify) ____________________	○ Always	○ Often	○ Rarely	○ Never

13	Do you integrate computer soft-media as part of your teaching practice? (See Q13 for Example of Soft-media)	☐ Yes	☐ No	☐ Sometimes
14	Which of the following computer soft-media do you use in your teaching?	☐ WWW Pages	☐ Audio	☐ Video
		☐ Graphics	☐ Generic Software	☐ Custom Built Software
15	How many years of experience do you have with using computer soft-media?	☐ No Experience	☐ Less than 1	☐ 1-3 Years
		☐ 3-5 Years	☐ 5-10 Years	☐ More than 10 Years
16	Do you have any formal training in the usage of computer soft-media?	☐ Yes	☐ No	
17	Do you have any external support[1] in developing your classroom computing environment[2] ?	☐ Yes	☐ No	☐ Sometimes
18	How do you structure your class while integrating PCs in your teaching?	☐ 1 on 1 with the PC (Time Limited)	☐ 1 on 1 with the PC (Task Limited)	☐ Pairs on the PC (Time Limited)
		☐ Pairs on the PC (Task Limited)	☐ Small Group on each PC	☐ Bigger Group (Class Size ÷ PCs)
19	Do you see any of the following as hinderances to your current teaching using PCs?	☐ Slow/Dated Computers	☐ Poor Quality Software	
		☐ Slow Internet Speed	☐ IT Support in Class	
		☐ Computer to Student Ratio	☐ IT Training	

20	Would you be able to increase productivity and learning if your class had more.	☐ Computers ☐ Software ☐ Access to Computer Media ☐ IT Support
21	Would you want to receive more formal training in certain technology?	☐ Yes ☐ No
22	Does any of your past non-technical training help you in your usage of Technology?	☐ Yes (Please Specify) ☐ No

APPENDIX 2

Ethical Considerations in Research with Teachers and Children on the Integration of Technology

According to the British Educational Research Association – "it may be self-evident that it is good to conduct research in education but it is nevertheless worth thinking about why this should be so and whether it is always true. Important questions emerge, such as: What is research for? Who benefits from research? What risks are involved?" (BERA Ethics and Educational Research, n.d.).

The nature of research, when we are identifying the benefits of student learning with the use of technology in schools, incorporates successful qualitative and quantitative analysis covering both the knowledge provider/educator and the learner (teachers and children). Therefore collecting the responses of both is essential, since the research can only move forward once their responses are collected and then analysed, helping us identify possible outcomes of the research. Children participation in such a situation is crucial since it provides us with a depth of information on their exact perspective and therefore research on other individuals cannot provide us the correct answers to questions posed to children.

However, before we start such a research, we need to understand that most educational research involves intruding in people's lives. Such an intrusion can have a significant impact on children and adolescents, since this group of society is especially vulnerable to exploitation, abuse, and other detrimental outcomes. To prevent such a situation we (the researcher) need to collect our data ethically.

In the case of research involving children, we should always follow the core ethical principle of putting the best interests of the child first; by protecting and supporting their wellbeing. This position is critical since, historically there is enough evidence of exploitation of children. Alderson and Goodey (1996) summarised that: "Children are marginalised in adult-centred society. They experience unequal power relations with adults and much of their lives is controlled and limited by adults: The main complications do not arise from children's inabilities or misperceptions, but from the positions ascribed to children" (p.106).

After centuries of neglect and no proper laws for protection, the past few decades dawned the first time when societies have realized and recognized that children are individuals and have rights. It was only in 1989, that the United Nations General Assembly approved the United Nations Convention on the Rights of the Child. This Convention (for the first time) acknowledges all children as human beings with inherent rights. Consulting with children in matters that influence them came as directives from such conventions that were established to oversee their appropriate application and to prevent abuse.

For ethical research, Beauchamp and Childress (2001) suggest that there are four principles that are the cornerstone of bioethics, however; Gorman (2007) suggests that these principles are applicable to almost all research projects. The principles are – Autonomy (from the Greek word *'autonomía'* stresses the idea of individuals knowing what is best for themselves), Beneficence (refers to actions that promote the well-being of others), Non-maleficence (This principle stresses an obligation not to inflict harm intentionally) and Justice (emphasizes that you should never commit a wrong act, even if the consequence is good). Let us look at each of the principles in the context of our research.

Autonomy is realised by giving the children and teachers the choice to participate (or not) and by giving their consent to being part of the research. But it does not end there; they should have the right to withdraw their participation at any time or stage of the research, if they feel uncomfortable or feel that it is not in their best interest to continue being part of the research.

Beneficence is realised by returning back the research to the students and teachers who were part of the project. After they have shared their ideas, issues and concerns on the use and integration of technology, the research must give them the opportunity to benefit from the recommendations. An example could be that based on the recommendations, the classrooms are reorganised so that the resources are shared using some scheme that comes out of the research (the dissolute thing would be to take the research and then sell it to some business that could profit from the very people and schools that supported the research).

Non-maleficence in our context is realised by looking at the research in great detail to make sure that no harm is accorded to the participants as being part of the research. The research could uncover some potential problems in the way the technology is being used, even if this information is to be shared to find a solution, the researcher needs to make sure that a grave level of anonymity is maintained at all times to protect his participants. Another dimension to this is that there needs to be an account of spin-off negative consequences that may arise from the research. For example the researcher could bring in some very advanced piece of equipment and support the teacher in their lessons however, once the research is complete and the data and responses collected, the researcher simply walks away with this equipment. There will be an impact on both the teacher and the students, which may have not been accounted for.

Justice will be realised by making sure that the recommendations and resources are properly and justly applied. That each student and teacher has equal access to the technology (based on their requirement) and that the limited resources are properly distributed in the classrooms, to make sure that every child can equally benefit from their application and availability.

Another point that can be added to enrich the four principles is Veracity (emphasizes honesty, and it is grounded in respect for persons and the concept of autonomy). Veracity is an element of Medical ethics however; I feel that it has value in every research. In our context, it provides the participants with the truth of what our research purpose is and provides the research with a level of transparency, thereby empowering the participants to make an informed decision as well as affording greater respect to their autonomy.

Ethical considerations enrich a project by providing a deeper moral footing to the research. Based on the applicability of the ethical views they safeguard the interests of participants as well as researcher, providing a level of assurance and moral awareness. Research with children especially needs to be carefully designed to make appropriate provisions to protect the vulnerabilities that come with being a minor.

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