HONG KONG CHEMISTRY TEACHERS' BELIEFS ABOUT AND PRACTICES OF USING INFORMATION AND COMMUNICATION TECHNOLOGY FOR TEACHING AND LEARNING

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ABSTRACT

The study focused on the use of information and communication technology or ICT based tools in chemistry teaching in secondary schools in Hong Kong. Local chemistry teachers were invited to participate in this study, as they are crucial in implementing ICT for teaching in schools. More specifically, the study aimed to develop an understanding on the following aspects.

1. What kinds of ICT-based teaching tools teachers are using?
2. What are teachers’ perceived usefulness and perceived ease of use of ICT-based teaching tools?
3. What are teachers’ context beliefs about the use of ICT-based teaching tools?
4. What are the relationships between the use of ICT-based teaching tools and teacher beliefs?

In order to answer these questions, a survey questionnaire was used to gather data about whether local chemistry teachers (N=124) were using ICT for teaching and how frequent were ICT tools being used. Then, in-depth interviews with five purposefully selected teachers, supplemented by document analysis were conducted. The data collected were analyzed using descriptive and inferential statistical analytical techniques, as well as constant comparison method. As there were no existing researches that focus on how local chemistry teachers make use of ICT, the findings of this study should contribute to the understanding in this domain. Furthermore, the findings could be illustrative reference for whether or not chemistry teachers in Confucian based societies like Korea, Malaysia, Singapore and Taiwan are using ICT for teaching.

A number of findings worth reporting are listed below.

1. Chemistry teachers are using ICT for teaching, but it is not the most frequently used strategy; also, they enjoy the use of ICT-based tools with a transmissionist oriented approach rather than a constructivist one.
2. Chemistry teachers have very positive perceptions that ICT-based tools are useful, and males show statistically significant more positive perceptions than females.
3. Chemistry teachers have positive perceptions that ICT-based tools are easy to use, and males show statistically significant more positive perceptions than females.
4. Chemistry teachers of high ability students, i.e. teachers working in schools with the majority of students belong to the first Territory Band, use more ICT-based tools than other teachers.

5. Chemistry teachers with the highest ICT competence use more ICT-based tools than others.

Plausible explanations of the findings like accountability practices and conflict of beliefs are then presented. At the end of the report, some pragmatic recommendations on how professional development programmes can be organized and the kinds of support chemistry teachers need are presented.
DECLARATIONS

I hereby declare that this dissertation represents my own work and that it has not been previously submitted to this university or any other institution in application for admission to a degree, diploma or other qualifications.

Production Note:
Signature removed prior to publication.

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Raymond Wai-hung FONG
March 2011
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1. Introduction

1.1 Background

The dissertation starts with a brief exploration of the history of using media or technology like the motion picture and radio which had been adopted for enhancing the quality of education. Why is it needed to have such an exploration? It is true that an exploration of the history, a window into the past, can provide all of us with insights for the present day practices. In particular, insights gained from once strongly advocated and then abated practices will be very useful reference for new attempts. In this study, the attempt is the use of information and communication technology (ICT) for teaching of chemistry in Hong Kong secondary schools.

A number of instructional design and technology (Reiser, 2001a) like school museums, instructional films, instructional radio and television were said to be great tools that would be a dominant part of the teaching process. Thomas Edison said in 1913, 

books will soon be obsolete in the schools ..... It is possible to teach every branch of human knowledge with the motion picture (i.e. instructional film). Our school system will be completely changed in the next ten years (cited in Reiser, 2001a).

It is clear that the motion picture has not changed any school system in a significant way.

In the early 1930s, the instructional radio was once again believed to be of great potential to revolutionize education (Reiser, 2001a). In a historical study, many teachers provided a number of reasons why radio was infrequently used: bad or no equipment, program scheduling, no information on programs, poor reception, and inappropriate programs (Cuban, 1986). Not all the aforesaid reasons are valid today, but it is crystal clear that the instructional radio did not have a noteworthy impact to classroom practices.
In the 1950s, there was an increased interest in television as a medium for delivering instruction. Just like the two instructional technologies mentioned above, the impact of instructional television on teaching and learning processes was very limited. According to the Carnegie Commission of Educational Television in the US that:

the role played in formal education by instructional television has been on the whole a small one .... nothing which approached the true potential of instructional television has been realized in practice .... With minor exceptions, the total disappearance of instructional television would leave the educational system fundamentally unchanged (Reiser, 2001a).

Cuban (1986) also stated that instructional television occupied a small portion of the school day. What went wrong with these technologies in that they could not secure a place in our classrooms? Will our current effort spent on promoting the use of ICT becomes obsolete in a short period of time, just in the same way as the motion picture, instructional radio and television?

It is time for us to focus on the use of ICT in teaching and learning. Since the 1980s, ICT has advanced rapidly with microcomputers getting more and more powerful, and various networks deeply penetrating into various walks of life. In the educational arena, teachers are also expected to demonstrate new teaching behaviours or to shift their current paradigm – integrate ICT into their teaching (ED, 1998). Given the paradigm shift, it is a common expectation that the use of ICT can enhance the quality of education, and effective use of education technology can improve student achievement (CEO forum, 2001; Lehtinen, et al., 2001). Papert indicated in 1984 that the computer was going to be "a catalyst of very deep and radical change in the educational system" (Reiser, 2001a). However, Reiser (2001a) reported a survey done in 1995 that although schools in the United States possessed on
average one computer for every nine students, that the impact of computers on instructional practices was minimal, with a substantial number of teachers reporting little or no use of computers for instructional purposes; and the use of computers was far from innovative. More than a decade ago, Cuban (1998) argued that computers are largely incompatible with the requirements of teaching. He also argued that it is simply too hard for most teachers to incorporate student computer use as a regular part of their instructional practice; computers are hard to master, hard to use, and often break down; therefore, investing effort into having students use them frequently is hardly worthwhile. More recently, Cuban, Kirkpatrick and Peck (2001) put forward their critical view on promoting the use of technology in teaching and learning, at least in the early stage of the promotion campaign that they do required strategies as well as support other than the practices that are widely adopted. In more concrete words, Cuban, et al. (2001) did not agree with the assumption that most policy makers, corporate executives, practitioners and parents made by wiring schools, buying hardware and software, and distributing the equipment throughout will lead to abundant classroom technology use by teachers and students, and improve teaching and learning.

More recently, just like the United States, many parts of the world injected a significant amount of resources (like a large number of computers being donated into schools and numerous professional development opportunities offered to teachers and principals) as a strategy to encouraging the use of ICT for teaching and learning in schools, however, numerous ICT researchers claimed that teachers are still not using technology based pedagogy extensively (Selwyn, 1999; Loveless, Devoogd & Bohlin, 2001; Kozma, 2003; Ertmer, 2005). The local Education Bureau reported, among other indicators of IT in education in Hong Kong, found that just over 50% of teachers frequently use ICT in class (EMB, 2005). Cuban (1998) summarized the phenomenon with the title “high-tech schools
and low-tech teaching". Does Cuban make the right claims outside the United States in different parts of the world? Does Cuban make the right claims that are still valid in the 21st century? To answer such questions it is essential to have studies that examine the current situation in schools and a detailed critical review of quality research reports published recently. Too often, teachers are said to be conservative and resist changes, and hence they are regarded as barriers to implementation of ICT in education. However, it is not appropriate to make such judgments without solid evidence gathered by systematic studies. Are there any context specific barriers standing in the way of integrating ICT into teaching and learning? Hence, a systematic scrutiny of teachers' knowledge, attitudes and beliefs in relation to the use of ICT may help.

Just before the local government launched the initiative "Information Technology for learning in a New Era Five-Year Strategy" (hereafter referred to as ITED project; ED, 1998), a survey conducted by the Hong Kong Policy Research Institute (Chow, 1998) revealed a drastic difference in the use of ICT in schools and in other sectors of the society:

- **Hong Kong is well-grounded on IT.** The government and public company sectors are well-equipped with desktop PCs (three persons sharing two PCs). The general work force in the commercial and public sectors are, in general, computer literate. Internet access in the public and private commercial sector is popular. Internet access at schools and homes are increasing, but still behind other business sectors. The reported Internet access in government are 88%, public companies 51%, small and medium enterprise 17%, schools 2%, and at home 7% respectively.
In marked contrast with the scenario in 1998, after several years of the implementation of the ITEd project, there was a completely different picture of the availability of computer and Internet access in schools as well as other sectors. The evaluation of the ITED project (EMB, 2004, p.1) in Hong Kong revealed that:

A survey conducted in early 2004 found that on average, each primary school had 91 computers while secondary school had 247. These are well above the original targets of 40 in primary schools and 82 in secondary schools under the Five-year Strategy (i.e. ITED project). All schools now have broadband connection to the Internet, with over 60% of them having fibre access and enjoying 10 to 100 Mbps bandwidth.

More recently, the Education and Manpower Bureau (EMB, 2005) reported the following indicators of IT in education in Hong Kong:

- The student-to-computer ratios are 6:1 in primary schools and 4:1 in secondary schools. This is comparable to the ratio of 5:1 in OECD countries, which are more advanced in IT in education such as the United Kingdom, United States, Australia and Canada.
- Nearly 90% of primary school students and nearly 60% of secondary school students like to use computers to learn in class.
- 85% of primary school students and 60% of secondary school students like to use computers to learn beyond school hours.

Thus, it is reasonable to suggest that the issue of access and connectivity in the ITED project (ED, 1998) is no longer a problem in Hong Kong. However, it is necessary to reflect judiciously on whether the provision of computers and Internet access to schools is a sufficient condition for the use of ICT for teaching and learning. In addition, it is also doubtful whether there has been a paradigm shift (ED, 1998) among teachers, the key stakeholders in classrooms. The evaluation report (EMB, 2004, p.2) also suggested that the extensive teacher enablement exercise was completed:
By the end of the last school year (2002/03), all teachers (about 50,600 including 4,600 teaching assistants) had completed IT training at the Basic Level, 35,600 (77%) teachers at Intermediate Level, 12,500 (27%) teachers at Upper Intermediate Level and 2,600 (6%) teachers at Advanced Level.

The figures can only be feeble evidence to suggest that there has been a paradigm shift (ED, 1998) among teachers. It is necessary to investigate whether the massive teacher enablement exercise is a warrant for the extensive use of ICT for teaching and learning at the classroom level. Furthermore, a more detailed scrutiny of the specification of the four levels of IT competency (Appendix A) revealed that there are only very limited emphasis on the significance of teacher beliefs on the use of ICT for teaching and learning. It is not possible to put forward arguments like “teachers are prepared and willing to use IT for teaching and learning” without a study on how teacher beliefs and other attributes affect their use of ICT-based teaching and learning tools.

Hakverdi, Gucum and Korkmza (2007) conducted a study in Turkey on the use of ICT in education and presented some arguments which could be used as a summary for this part of the discussion: limited access to computers may no longer be a significant factor in teacher’s computer use; instead, factors like teacher’s perceived computer self-efficacy and computer experience, age, gender etc. may be more significant. Though it is not possible to argue what Hakverdi, et al. (2007) suggested from their study will be perfectly valid in Hong Kong, the scenarios they described bear close resemblance to that of Hong Kong, the arguments they presented worth some deliberation.
1.2 Why study teacher beliefs?

Cornu (2003) states that "(first phase) ... ICT has first emerged as new concepts, new tools, new resources, with no evidence that it could be used in education; (second phase) then they (teachers) started applying ICT to their professional activity, looking at how teaching could be changed by the use of new tools ... (third phase) teachers went to the integration of ICT into education ...". With reference to the three phases mentioned in Cornu's report and the current situation in Hong Kong, the use of ICT in education in Hong Kong should no longer be new concepts, new tools and new resources – not the first phase; however, it is not possible to say definitely whether ICT in education falls in the second or the third phase. Thus, it is a worthwhile study to develop an understanding about the current status of the use of ICT in education, and to further explore the means that can facilitate the transition from the second phase to the third.

Just like many educational reforms, a number of factors can facilitate or hinder the change processes. To make a change successful, many factors have to be addressed. Fullan (1999), a renowned expert in managing changes in the educational arena, mentioned "educational change depends on what teachers do and think – it's as simple and complex as that". Zint (2002) concluded from an analytical point of view that "reform without sufficient care and attention towards teachers' beliefs resulted in insignificant change or not functioning". Pajares (1992) also opined "attention to the beliefs of teachers and teacher candidates should be a focus of educational research and can inform educational practice in ways that prevailing research agendas have not and cannot". Should there be a call for teachers to change their practices, including the use of ICT for teaching and learning, what teachers think and believe have to be scrutinized with care.
In the well-known longitudinal study on ICT in teaching and learning, Apple Classrooms of Tomorrow (ACOT), Dwyer, Ringstaff and Sandholtz (1990) argued that it is nothing new to observe that deeply held beliefs can stand in the way of change. Furthermore, they suggested that there is evidence for the fact that teacher beliefs about instruction and schools are important factors that underlie the institution's resistance to change. The ACOT study also put forward the following logical and reasonable argument: a belief system shaped by years of involvement with traditional school structures causes teachers inner conflict when they attempt new instructional approaches, especially involving technology (Gifford, 2004, p.6). The inner conflict mentioned can be used to explain the gap between the expected (new paradigm called for by ITED project) and the actual use of ICT for teaching and learning (existing paradigm). Teachers believe their practices are effective teaching and learning strategies, and the use of ICT in education can only be equally good or can be even inferior.

Just like other educational changes, teachers will start to consider adjusting their usage of ICT in education if there are strategies and practices that help firstly to remove what Ertmer (1999) termed extrinsic or first-order barriers: lack of access to computers and software, insufficient time to plan the instruction, and inadequate technical and administrative support. In addition, strategies and practices have to be in place to addressing intrinsic or second-order barriers: beliefs about teaching, beliefs about computers, established classroom practices and unwillingness to change. Furthermore, factors like personal accountability, students' abilities, curriculum constraints, examination requirements etc. have to be explored in order to paint the "whole picture of ICT in education". With reference to the two types of barriers, it is possible to argue that the first-order barriers can be solved without too much difficulty provided sufficient resources are available; the second-order barriers cannot easily be circumvented as they are related to some implicit and deep-rooted
personal attributes. In the case of Hong Kong, according to the information provided by the Education and Manpower Bureau of the Hong Kong SAR government (EMB, 2004, p.1-2), a very good ICT infrastructure is available in all schools in Hong Kong. It is appropriate now to consider how to make good use of such an IT-rich learning environment. In other words, it is necessary to have a good understanding of second-order barriers encountered by local teachers.

On the use of ICT in education, Albion (1999) suggests graduates (from teacher education programmes) should possess both skills in the use of ICT as well as belief in their capacity to integrate ICT into teaching. Based on a study involving more than 300 pre-service science teachers, Hakverdi et al. (2007) put forward arguments like "programs in education faculties should be restructured to give enough opportunities to their pre-service teachers to improve their personal efficacy and outcome expectation in the use of technology".

According to Becker (2000), computers serve as a "valuable and well-functioning instructional tool" in schools and classrooms in which teachers: (a) have convenient access, (b) are adequately prepared, (c) have some freedom in the curriculum and (d) hold person beliefs aligned with a constructivist pedagogy. In other words, it is possible to argue there are four conditions to meet so that computers or ICT will be used extensively in classrooms in the same way as we are using a blackboard now.

With reference to what Becker (2000) suggested, it is necessary to examine the four said conditions in Hong Kong so as to attain the target: the computer becomes a valuable and well-functioning instruction tool.

As mentioned previously, the evaluation report of ITED project (EMB, 2004) suggested that teachers have good access to computers and they are quite well prepared. In addition to
what happened in schools, the Census and Statistics Department of the local government reported: as at 2007, about 3.96 and 4.06 million persons age 10 or above had used personal computers (PC) and Internet respectively (CSD, 2008). The report also suggested:

Both the percentages of households with PCs at home and those with their PCs (excluding palm tops and PDAs) at home connected to Internet had increased significantly over the past several years ...

The corresponding percentages increased from 49.7% and 36.4% in 2000 to 74.2% and 70.1% in 2007 respectively.

With reference to the statistics in Hong Kong, it should be noted that most teachers have knowledge of computers and a reasonably good salary. Consequently, they will have PCs which are connected to Internet using broadband connections. Will the availability of Internet ready computers be a sufficient and necessary condition for teachers to be using ICT for education?

After all, perhaps teacher beliefs and their use of ICT are the least investigated themes. Also, the said themes are very important aspects of integrating ICT into teaching and learning practices, or to meet the call for paradigm shift (ED, 1998).

To sum up briefly, a research into teacher beliefs on aspects of ICT and teaching and learning is needed to understand and subsequently modify the process of institutionalization of ICT into classrooms. This study is an attempt to examine how chemistry teachers' beliefs are related to their use of ICT-based teaching and learning tools. Some specific and important constructs like perceived usefulness of ICT and perceived ease of use of ICT (Davis, 1989), & context beliefs about technology (Lumpe & Chambers, 2001) in teaching and learning processes will be included in this study. Please refer to Section 1.6 for details.
1.3 Terminology: technology, information and communication technology, and information technology

One of the key aspects of this study is to examine how teachers use ICT in teaching and learning. With reference to the use of computer based teaching and learning technology, for various reasons, different districts or countries adopted different terms. For example, Department for Education and Skills (DfES) of United Kingdom adopted the term "information and communication technology (ICT)", the U.S. Department of Education preferred the term "technology" or "education technology", and Education Bureau of Hong Kong SAR used the term "information technology (IT)". To avoid readers being confused by the terms used, it is imperative to clarify the key term for describing computer based teaching and learning technology in the early part of this thesis.

In the USA, the term "technology" is quite commonly used for referring to computer related or associated teaching and learning technologies. For instance, the International Society in Education (ISTE) publishes journal called Learning and Leading with Technology with most of the articles talking about computer based teaching and learning technology. In almost the same manner, the Advancement of Computing in Education publishes the Journal of Technology and Teacher Education with a large number of articles talking about computer related technologies.

As mentioned before, DfES of United Kingdom refers to computer related teaching and learning technology as information and communication technology. The term ICT is used as a school subject name at GCSE level as well as a teaching and learning strategy to be used in different subjects. British Educational Communications and Technology Agency (BECTA), UK Government's lead agency on the use of ICT in education, published many different reports on the use of computer-based technology in education. However, they will use
different terms like ICT and technology in an interchangeable manner. Two recently published reports by the same education agency are good illustrations here.

- Making the most of your investment in ICT (BECTA, 2006)

In Hong Kong, the term information technology is more commonly used in policy documents and reports. For instance, Education Department of Hong Kong SAR published two key reports: Empowering Learning and Teaching with Information Technology (EMB, 2004) and Information Technology for Learning in a New Era Five-Year Strategy 1998/99 to 2002/03 (ED, 1998), using the term information technology. However, the term ICT has been used as the new subject name in the coming new senior secondary curriculum (CDC, 2007). Also, some academics use the term ICT rather than IT in their publications (Law, Yuen, Ki, Li, Lee & Chow, 2000).

To finish off this part of the discussion, as Albion (2000, p.3) argued, the term ICT has wider international currency than any of the said alternatives and is unlikely to be misunderstood even where it is not in common use, hence, the term ICT will be used in this thesis. However, it is also important to avoid erroneously communicating the ideas and concepts in the articles published in different parts of the world which have been included in the literature review, the original terms like technology and information technology will be preserved as far as possible.
1.4 Significance of the study

It is anticipated that this research will shed light on some aspects like how teachers use ICT in their teaching and learning, their context beliefs about teaching and learning, their perceived usefulness of ICT for facilitating students' learning, and their perceived ease of ICT use. Thus, it is possible to develop a picture of the usage of ICT in teaching and learning. In addition, it is expected that teachers are using ICT in an informed way, i.e. teachers will adopt different ICT-based tools according to a set of clear criteria. In this connection, this research should help to develop an understanding of the relationship between ICT usage and other selection criteria. The relationship can then be used to predict the adoption of ICT-based tools in classrooms, if not globally, at least in the local society.

The outcome of this research should be able to inform teachers' professional development practices (Lundeberg & Levin, 2004; Albion, 2003) and should provide clues on how to support teachers' use of ICT for quality education.

Albeit the study does not include pre-service teachers as the subjects of study, the results of this study should provide insights on how pre-service teacher education programmes should be developed or modified for the 21st century. For instance, should some pre-service teachers not be willing to use ICT-based tools, it may be related to their capability beliefs but not their epistemological beliefs; if that is the case, a sound pre-service education programme for these teachers should stress ways to improve teachers' ICT competency. The instruments used in this study can be used to assess their training needs.

This study should also provide information for policy makers and school administrators on how to invest their budget wisely on professional development programmes for in-service
teachers for better results. For example, policy makers can consider putting the major share of a budget on professional development programmes for enhancing teachers' beliefs rather than on upgrading hardware and software. Furthermore, the instruments used in this study should also be used to assess teachers’ specific ICT training needs, with the assessment result to make informed decisions on the training need.

In short, this study should be able to build knowledge related to teachers' beliefs and to provide some insights relevant to the development of strategies for promoting the use of ICT-based teaching and learning tools.

1.5 Research questions

Having discussed the background information, why study teacher beliefs and the significance of this study, it is appropriate now to outline the four main research questions. To focus the study, three constructs related to teacher’s beliefs – perceived usefulness of ICT, perceived ease of use of ICT and context belief – will be scrutinized in this study. Furthermore, some attributes of teachers will also be studied. The questions listed below attempt to reveal the relationship between teacher’s beliefs and their decisions on the use of ICT-based teaching and learning tools.

1. What kinds of ICT-based teaching and learning tools are teachers using?
2. What are teachers’ perceived usefulness (PU) and perceived ease of use (PEoU) of ICT-based teaching and learning tools?
3. What are teachers’ context beliefs (CONTX) about the use of ICT-based teaching and learning tools?
4. What are the relationship between the use of ICT-based teaching and learning tools and teacher beliefs (as exemplified by PU, PEoU and CONTX)?
1.6 Definition of terms

Irrespective of the research discipline, it is essential to include in this thesis a comprehensive list of definitions of all the variables involved. With this in mind, this section is an important one in the sense that all key variables in this study will be operationally defined here, and how they will be scrutinized.

a. Information and communication technology:

As clarified in Section 1.3, information and communication technology refers to the commonly used computer based software tools for teaching and learning in secondary schools. A number of software classification systems like those proposed by Taylor (1980), Alessi and Trollip (2000) and Means, Penuel and Padilla (2001) can be good references here.

- Taylor (1980): three categories of computer based instruction – tutor, tutee and tool
- Alessi and Trollip (2000): five categories of computer based instructions - tutorials, drills, simulations, games and tests
- Means, Penuel and Padilla (2001): four categories of educational technologies based on their uses – used as tutor, used to explore, used as a tool and used to communicate

Nevertheless, the abovementioned classification systems are not comprehensive. Some basic software, like web browsers, have not been included, and most of them are teacher oriented ones. In this study, a number of computer-based software tools for teaching and learning are included (Wong & Li, 2006), for instance, collaborative learning tools such as e-Group has been included. On the contrary, a number of ICT-based tools like email clients and web servers are not included, as they are not directly related to teaching and learning, and their exclusion should avoid respondents’ being overloaded with excessive information. Please refer to Section A of the survey questionnaire (Appendix C) for details.
Teacher beliefs can be hard to define, messy and abstract psychological constructs (Pajares, 1992). Without a concrete concept of what beliefs refer to, any study on them will yield facile results or findings. For this particular study, three belief-constructs namely perceived usefulness, perceived ease of use and context belief will be included.

1. Perceived Usefulness (PU)

Davis (1989) defined PU as the degree to which a person believes that using a particular (information) system would enhance his or her job performance. It can be said PU is a belief construct which is related to a personal mental evaluation of whether the system concerned will be useful to a person’s job. For this study, the PU is defined using the generic term “ICT in teaching and learning” instead of pinpointing a specific “information system”. In other words, the PU will be the aggregated score of the Likert’s scales of the five questions in Section B1 of the survey questionnaire (Appendix C).

2. Perceived ease of use (PEoU)

According to Davis (1989), PEoU is the degree to which a person believes that using a particular (information) system would be free of effort. Alternatively speaking, PEoU is a belief construct related to a personal mental evaluation of whether the system concerned will be easy to use. The construct should be closely related to what Enochs, Riggs & Ellis and Bandura referring to “efficacy belief” (cited in Lumpe, Haney & Czerniak, 2000) and what Lumpe and Chambers (2001) refers to as “capability belief”. For this study, just like the case of perceived usefulness, the PEoU is defined using the generic term “ICT in teaching and learning” instead of pinpointing a specific “information system”. In other words, the PEoU is the aggregated score of the Likert’s scales of the five questions in Section B2 of the survey questionnaire (Appendix C).
3. Context Beliefs (CONTX)

Lumpe and Chambers (2001) studied factors that affect teachers' uses of technology for teaching and learning, and argued that context beliefs are important constructs to be examined. Context beliefs are what teachers believe about factors that enabled them to be effective teachers, and the likelihood of those factors occurring in their schools. According to Lumpe, Haney and Czerniak (2000), context beliefs are also called perception of control, perceived behavioural control and outcome expectancy. For this study, the CONTX is defined using two subscales: "factors that would enable me to be an effective technology using teacher" and "likelihood the factors will occur in school" (Lumpe & Chambers, 2001). In other words, the CONTX are the aggregated score of the two Likert's type subscales of the 14 questions in Section C of the survey questionnaire (Appendix C).
2. Literature Review

2.1 Development of the use of ICT in education

For a period of more than 30 years, researchers like Suppes (1966), Papert (1980, p.18) and Stolier and Conlin (1985) put forward a positive expectation of the use of computer in education:

... the entire educational system will begin to revolve increasingly around the computer. Combined with teachers and parents, books and classrooms, the system over the next few decades will change. At the core of it will be the computer (1985, p.10).

However, systematic studies of the use of ICT in Hong Kong by the Hong Kong Policy Research Institute (Chow, 1998) and the SITE study (Law, 1999) suggested that computers are usually used for learning ICT. In 2007, Chin portrayed the following scenario on how ICT was used for teaching and learning in Hong Kong.

The computer is now a ubiquitous part of our school system, at all levels. Still old habits die hard. Hong Kong has not yet made the necessary paradigm shift to take full advantage of the technological wonders that IT offers. Specifically, I would hope to see IT technology transforming our learning and teaching experience to greatly benefit our students.

In short, the use of ICT for teaching and learning is at best labeled as "infant stage". The computer has not become the core of the entire educational system in Hong Kong.

Recently, the expectation of students to have the ability to use 21st century tools (i.e. ICT) has been spelled out clearly by in the APEC Education Ministerial Meeting 2004 held in Chile.

ICT literacy is essential for our students to participate meaningfully as citizens of an interconnected and knowledge-driven world. (APEC, 2004)
Stakeholders in the education sector expect more use of ICT for increasing effectiveness and efficiency of learning. ICT is also regarded as a tool for self-directed and life-long learning in Hong Kong (CDC, 2001). Chin (2007) argues that:

Making effective use of IT technology to enhance learning and teaching does not mean merely digitizing the textbooks, putting lecture notes on the Web, or submitting home work assignments online. The entire approach must be student-centered, not technology-centered. That is to say, the approach must cater to the individual learning needs of students, not merely for the convenience of teaching, or to keep up with fashionable technology trends.

Similarly, Cuban, a researcher working in the United States on using technology in education, suggested three goals for making new technologies available in schools:

1. More productivity through better teaching and learning.
2. Transform teaching and learning from traditional textbook lessons to more learner-friendly, student-centered approach.
3. To help students sufficiently computer literate to compete in a workplace that demands high-level technological skills. (Cuban, 2001, p.177).

How can the second wave of educational reform on using ICT be resolved more successfully?

Kozma (2003) carried out a large scale meta-research on the use of technology in classrooms and published the report using the title "Technology and Classroom Practices: An International Study". The research was a synthesis from a large number of case studies on "innovative pedagogical practices". He examined the findings from 174 case studies from 28 countries participating in the Second Information Technology in Education Study Module 2 (SITES M2). Thus, it is possible to develop some understanding about ICT classroom practices worldwide by reading Kozma’s article.
Kozma deployed a technique 'cluster analysis' as the main data analysis tool. Seven patterns of classroom practice were identified; they are, 'tool use', 'student collaborative research', 'information management', 'teacher collaboration', 'outside communication', 'product creation' and 'tutorial'. In addition, with referenced to the case reports, Kozma reported the trends of classroom practice using four perspectives:

1. ICT was integrated throughout the curriculum.
2. Most of the teachers were engaged in advising and guiding their students. Also, the impact of ICT on teachers was primarily the development of their ICT skills and pedagogical skills.
3. Students were collaborating with each other in the innovative practices.
4. The most common kinds of technology used by teachers and students were 'productivity tools', 'web resources' and 'e-mail'.

However, whether all the cases reported are a representative sample of common classroom practices or they are atypical or extreme cases should be considered with care.

Another important finding was the stated impact of the innovation on students was quite broad. The following claims were common: 'acquire ICT skills', 'develop positive attitudes toward learning or school', 'acquire new subject matter knowledge', and 'acquire collaborative skills'.

With referenced to these findings, it is possible to suggest that teachers and students have acquired basic ICT skills and they should have no problems in using ICT. It is logical to suggest more research should be carried out to study on ways of using ICT to enhance teaching and learning in different curriculum areas. Furthermore, it is important to consider why other aspects of technology like simulations and microcomputer-based laboratories (NSTA, 1999) were underused.
Beyond the clustering of classroom practices, Kozma also reported cases in an information management cluster and a student collaborative research cluster were more likely to be associated with 'reported' outcomes. Even though the outcomes were not verified in any way, the findings deserve further investigation as most of the ICT classroom practices were associated strongly with a view to improve student's learning outcomes, in cognitive, affective or psychomotor domains.

Kozma (2003) reported two key findings from his study which examines the findings from 174 case studies of innovative pedagogical practices using ICT from 28 participating countries that

- there were significant changes in teaching, learning, or curricular practices, and
- ICT played a significant role in supporting these changes.

Furthermore, he put forward the following evidences to support his finding:

- Students are working together in teams and using computer tools and resources to search for information, publish results, and create products.
- Teachers are using ICT to change their role from that of primary source of information to one who provides students with structure and advice, monitors their progress, and assesses their accomplishments (p.13).

UNESCO (2002) also put forward similar ideas that ICT play a key role to support the change from a traditional learning model (teacher-centred instruction) to a new one (student-centred learning). For instance, teachers can made use of internet connection available in schools to transform "passive learning" to "active/exploratory/inquiry-based learning"; and with social software (Bartlett-Bragg, 2005) to facilitate students to work collaboratively to solve authentic problems rather than in isolation on artificial questions (UNESCO, 2002, p.59).
ICT plays a pivotal role in supporting the change from the traditional learning paradigm and to the new paradigm (ED, 1998). According to White (2005), ICT can provide teachers with an information and communication technology enriching learning space. In other words, ICT based tools can be one of the enablers of the use of the new paradigm for teaching and learning.

2.2 ICT in science education

In the USA, the Board of Directors of the National Science Teachers Association (NSTA, 1999) adopted the position statement "The Use of Computers in Science Education". The position statement proposed five guidelines for the implementation of computers in the teaching and learning of science:

1. Tutorial software should engage students in meaningful interactive dialogue and creatively employ graphics, sound, and simulations to promote the acquisition of facts and skills, promote concept learning, and enhance understanding.

2. Simulation software should provide opportunities to explore concepts and models which are not readily accessible in the laboratory, e.g., those that require:
   - expensive or unavailable materials or equipment
   - hazardous materials or procedures
   - levels of skills not yet achieved by the students
   - more time than is possible or appropriate in a real-time classroom, e.g., population growth simulations.

3. Microcomputer based laboratory devices should be used to permit students to collect and analyse data as scientists do, and perform observations over long periods of time enabling experiments that otherwise would be impractical.
4. Databases and spreadsheets should be used to facilitate the analysis of data via their organizational and visual representation capabilities.

5. Networking among students and teachers should be encouraged to permit students to emulate the way scientists work and, for teachers, reduce teacher isolation.

The Association of Science Education (ASE), UK, believes that:

IT is an essential part of the education of all learners, and that scientific understanding is enhanced by appropriate use of IT. Learning of science is enhanced by IT, and in addition IT skills are enhanced by their applications to science (ASE, 2000).

Furthermore, the ASE considered that educational institutions should be encouraged to support science teachers in their attempts to bring ICT into the science curriculum. This requires recognition that ICT facilities were as essential a feature of science equipment as magnets and microscopes.

BECTA (2003) reported the applications of ICT in science education based on the information obtained from various ICT research reports done mainly in the UK. The applications of ICT in science education could be divided into four broad areas: 'data handling', 'information', 'communication' and 'exploration'. Furthermore, each of these areas cover a range of software and hardware as listed in Table 2.1.
Table 2.1  BECTA’s classification of the use of ICT in science education

<table>
<thead>
<tr>
<th>Area</th>
<th>Hardware and software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data handling</td>
<td>Data logging tools and digital video cameras for data capture</td>
</tr>
<tr>
<td>Information</td>
<td>Spreadsheets and graphing tools for data handling and analysis</td>
</tr>
<tr>
<td>Communication</td>
<td>Information resources such as the internet and CD-ROMs</td>
</tr>
<tr>
<td>Exploration</td>
<td>Simulations and modelling tools, including animations and virtual environments</td>
</tr>
</tbody>
</table>

The report also spelled out explicitly “factors for effective use”.

1. ICT should be used only when appropriate to lesson objectives
2. Pupils need autonomy to explore and test their ideas
3. Teachers should encourage discussion and interaction between pupils
4. Teachers should ensure that pupils have the necessary information literacy and analytical skills
5. Time saved through ICT needs to be used effectively
6. Training should be provided in a range of different ICT applications, with time for teachers to develop confidence by exploring them independently
7. Laboratory design must allow ICT to be integrated safely and easily into practical work
8. Reliability and the provision of technical support are crucial

(BECTA, 2003)

These factors can be grouped into different areas. For instance, factors like 1, 5, 7 appear to be working principles; factors 3 and 6 are linked with teacher attitudes and intentions. However, listing these factors alone is not a sufficient and good way to develop understanding about the complexity of using ICT in science education.

In Hong Kong, a science educator and researcher described a conceptual framework for teaching and learning science with ICT (Cheng & Li, 2002).
The researchers suggested the framework for clarification of the dynamic interaction of the three dimensions: content, learning environment and ICT. The interaction informed appropriate use of the teaching and learning strategy. Furthermore, the researchers also stressed the importance of including an appropriate learning theory in the framework.

The framework is a move toward a complete understanding of ICT-based pedagogy. It is a comprehensive and logical framework. Nevertheless, it lacks clarification on who decides what learning theories are to be used? Can teachers make the decisions? Will policy makers, administrators or someone higher up in the hierarchy have full control? Also, how the three dimensions interact is not fully discussed. As an example, the framework provides a hazy idea on whether it is desirable to deliver science content knowledge by teachers via ICT.

It would be quite difficult to provide a summary of the recommendations and ideas made by these organizations and academics, however, they agree that ICT should be used in teaching and learning science, and ICT would help students and teachers to accomplish their tasks.
more effectively in a new way. More specific, ICT provides science teachers and students a number of advantages like “new ways of communication between teachers and students, e.g. instant messaging systems”, “new tools for data analysis, e.g. spreadsheet for data crunching”, “just-in-time learning, e.g. Youtube for learning how to carry out a solvent-solvent extraction”, “customization of learning for individual learner, e.g. graded assignment for students of different abilities”, “learner control or self-regulated learning”, “scaffold learning in virtual laboratory, e.g. Model ChemLab”, “learning with multimedia, e.g. ChmSet 2000”, “trouble free publication on the web, e.g. wikis, blogs and podcasts” (Collins & alverson, 2009; Richardson, 2009; White, 2005). To conclude, the advent of ICT provides teachers and students numerous tools for teaching and learning.

2.3 ICT-based teaching and learning orientations and practices

Baumgartner and Heyer (2007) contended that there are three different paradigms for teaching and learning.

1. "Teaching Mode I" refers to a learning environment in which teachers attempt to transfer propositional knowledge to students by teaching and explaining; and “Learning Mode I” refers to students being encouraged to know and remember the provided knowledge, and to produce correct answers when assessed. Teachers using this paradigm will have complete control of the learning process and the communication is often one-way.

2. "Teaching Mode II" refers to a learning environment in which teachers attempt to present predetermined problems to students by demonstrating, observing and facilitating; and "Learning Mode II" refers to students being encouraged to do and practice, and to solve problems. Teachers using this paradigm will share the responsibility of learning process with their students, and the communication is predominately dialogue in nature.
3. "Teaching Mode III" refers to a learning environment in which teachers attempt to provide students with opportunities to learn through action in authentic situations. Teachers have to cooperate with and to support students. "Learning Mode III" refers to students being encouraged to overcome challenges through actions. Teachers using this paradigm will have to support and guide, and students will be responsible for their own learning, or alternatively they need to be engaged in self-directed learning.

The key concepts of the three different teaching modes and learning environments are summarized in Figure 2.2.

![Figure 2.2 Teaching modes and learning environments (Baumgartner & Heyer, 2007)]
Camilla Gobbo and Marta Girardi published their research using the title “Teachers’ Beliefs and Integration of Information and Communications Technology (ICT) in Italian Schools” in 2001. They attempted to explore a relationship between classroom ICT practices and teachers’ personal theories about teaching and learning and their ICT competence.

They approached the research question by firstly define or operationalize the complex, amorphous and ill-defined concept ‘teaching style’. They located a number of relevant articles and adopted the model suggested by Maar and Taylor (1995) as the conceptual framework for the concept ‘teaching style’ for this research. Whether Maar and Taylor’s model is the best available remains unknown and a closer examination will be needed. After that, they defined the other two variables, ‘level of competence in ICT’ and ‘how ICT is integrated into classroom activities’. The three variables were then elaborated as follows.

Table 2.2  Gobbo and Girardi concepts: teaching styles, ICT competence and how ICT is integrated into classroom activities

<table>
<thead>
<tr>
<th>Teaching Style (Personal theories of teaching and learning, and perception of teaching practices)</th>
<th>Transmissionist Orientation</th>
<th>Personal Constructivist Orientation</th>
<th>Social Constructivist Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of competency in ICT</td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>How ICT is integrated into classroom activities</td>
<td>Frequency of use with measure unit like hour per week</td>
<td>Modes of use like ICT as tools to aid teacher-centred lectures or ICT as tools for student-centred Internet based learning activities</td>
<td></td>
</tr>
</tbody>
</table>

The three teaching styles listed by Gobbo and Girardi (2001) are somehow closely related to Teaching Mode I, II and III suggested by Baumgartner and Heyer (2007).
Gobbo and Girardi (2001) described in the result section of their report that the great majority of the teachers found positive aspects regarding the use of the computer in the school context. However, teachers did not show an uncritical acceptance and did not look forward to replacing traditional teaching in every aspect. This is indeed a piece of concrete evidence for teachers' professionalism in the teaching and learning aspect. This is also an important aspect of managing changes in educational practices to be considered by policy makers, curriculum leaders and practitioners. Furthermore, the researchers reported there were changes (in teaching and learning) after the introduction of the computer, some teachers reflected and put in effort to 'accommodate' ICT in their teaching styles while others 'assimilate' ICT into existing models and routines (Loveless, DeVoogd & Bohlin, 2001). These arguments are in line with the notion suggested by Noss and Pachler (1999), "The Challenge of New Technologies: Doing Old Things in a New Way, or Doing New Things?" (p.195).

The research also indicated teachers hold epistemological beliefs about the teaching-learning relationship – a teacher-centered perspective or a student-centered view. Is it appropriate to alter the epistemological beliefs of teachers? If yes, what should educational leaders or policy makers do? Furthermore, should we do something to change the context or should leave the context per se?

According to Yu (2005), local teachers are very often using "Teaching Mode I" in their classrooms. Hong Kong is one of the many Chinese societies under the influence of Confucian collectivistic culture. Teachers are generally being regarded as knowledge experts and hence knowledge transmission is the most important teaching approach for enhancing students' learning. In addition, teachers do play the pivotal role in selecting, organizing and presenting teaching materials in their lessons. Formal exposition based
strategies like lecturing, modelling, instructing, illustrating and demonstrating are the main teaching strategies of a teacher-centred approach (Brown, 1998; Castling 1996; cited in Yu, 2005). Students are not expected to put up challenges for teachers and to interact with fellow students. In short, teachers are getting very accustomed to supreme authority over their students. This unique status of teachers in Confucian culture leads to a de facto standard of the use of teacher-centered teaching approach in Chinese societies. Are local chemistry teachers using the same approach in their lessons as described by Yu (2005)?

At the very early stage of the 21st century, the local Curriculum Development Council (CDC, 2001) stated clearly that school students are expected to possess generic skills like communication skills, problem solving skills, critical thinking skills and study skills. In the US, a very similar set of standards is suggested for students:

- creativity and innovation,
- communication and collaboration,
- research and information literacy,
- critical thinking, problem solving, and decision making,
- digital citizenship, and
- technology operations and concepts (ISTE, 2010).

The recent transition from an industrial-based society to knowledge-based one will need to be supported with students equipped with 21st century competency (White, 2005). Teachers are therefore expected to provide their students with learning opportunities for the development of "know-how" and "knowing-in-action". In other words, local students should have the capability of "know-how" and "knowing-in-action" in order to fit into a knowledge-based society which in turn fit into a globalized world (Friedman, 2005).

Siemens (2005) took the discussion a bit further and opined "Connectivism" as a new theory of learning. The theory describes learning occurs as "distributed within a network, social,
technologically enhanced, recognizing and interpreting patterns” and is facilitated by the ease of access to “diversity of network”. Furthermore, Siemens (2005) argued that the theory is particularly suitable for the type of learning with the following attributes: complex in nature, rapid changing core knowledge and diverse knowledge sources. In short, students have to be equipped with a new way of learning in a vibrant and ever-changing world.

The above mentioned expectations on students do have implications for local teachers: teachers are required to make paradigm shift from using “teaching mode I” to “teaching nodes II and III” and design learning environments conducive to “learning modes II and III” instead of solely “learning mode I”. The paradigm shift can be catalyzed with the use of ICT for teaching and learning. As an example, instead of deploying a presentation on the role of science in protecting the environment by providing solutions to manage air pollutants, teachers can make use of social software like blog (Bartlett-Bragg, 2005) to help students to reflect on the topic and then communicate their reflections to various stakeholders without technical challenges (Richardson, 2009). Students can develop critical thinking skills through information search and self-reflection. With the deliberate arrangement for students to read and comment on fellow students' blog messages, students can develop knowledge and skills in a collaborative manner. The said pedagogical arrangement could be said to be a paradigm shift: a change expected in the policy document “Information Technology for learning in a New Era Five-Year Strategy 1998/99 to 2002/03” (ED, 1998).

Given the fact that there are virtually no information on how local chemistry teachers make use of ICT for teaching and learning, it is hoped this study will shed some light on this aspect.
Teacher beliefs

From the literature, a few academics put forward the idea that a person’s perceptions are important predictors of one’s behaviours. Hence it will be a pragmatic practice to scrutinize one’s perception in order to understand why one demonstrates a particular behaviour. For instance, Savery (2002) argued that examining the perceptions of educators is a widely used strategy in education research based on the premise that perceptions matter and often influence behaviors. Belcheir and Cucek (2002) also used the same approach to study faculty perceptions of distance education in a tertiary education institute, while Cope and Ward (2002) used a phenomenological research approach to examine the importance of high school teacher perceptions on the integration of learning technology in classrooms (p.72).

With a little reflection from the researcher’s experience in the educational arena, it is not difficult to appreciate the importance of teachers in embracing classroom-based innovations. It is again not a surprise to find remarks made by a number of researchers that changing pedagogical practices must address teacher beliefs, and that teacher belief is an often neglected area of implementing changes. Ballone and Czerniak (2001) argued “... the teacher is the critical change agent in paving the way to education reform and that teacher beliefs are precursors to change”. Pajares (1992) stated “the understanding of belief structures of educators is essential to improving teaching practices as they ultimately affect the behaviour of the teacher in the classroom” (cited in Ballone & Czerniak, 2001, p.8). Hence, it is imperative to construct a theoretical framework for this research linking beliefs and behaviours.

Over the last three decades, a number of academics including Bandura (1977), Ajzen (1985), Fishbein (2000), Bagozzi and Warshaw (1990) and Ford (1992) were working on theoretical
conceptions about the relationship between attitude, intention, motivation and behaviour.
In this connection, they proposed a number of theories like "Theory of Self-efficacy", "Theory of Reasoned Action", "Theory of Planned Behaviour", "Theory of Trying" and "Motivation and Personal Agency Beliefs Theory". In addition, Davis (1989) also put forward a "Technology Acceptance Model" to outline how technology acceptance and perceptions are linked.

Albeit the theories have quite distinct names, they attempted to figure out the determinants for predicting certain behaviour. Numerous studies in various fields were based on these theories. Furthermore, the theories are not working specifically with the target subject group of this research, i.e. chemistry teachers; nonetheless the theories can be a valuable reference for developing a theoretical framework for this research. The sections that follow will be used to outline these theories very briefly.

2.5 Theory of reasoned action (TRA)

Ajzen and Fishbein (1980) put forward a generic theory with a view to explain how people made decisions for different actions. They considered that people would perform a particular behaviour based on a rational decision. Hence, they named the theory as theory of reasoned action. In addition, they suggested two constructs, namely attitude and subjective norm, for predicting a person's behavioural intention, which is a measure of how likely a person would carry out a particular behaviour. Furthermore, they argued that the two constructs could not predict behaviour directly, but only the intention to act.

The theory of reasoned action, proposed by academics like Ajzen and Fishbein, stated that a voluntary behaviour (B) can be predicted from individuals' intention to perform the behaviour (BI), which in turn is determined by two determinants: attitude toward the
behaviour (AB) and subjective norm (SN). The two determinants can be elaborated as follows,

- Attitude toward the behaviour – the evaluation of the behaviour as favourable or unfavourable
- Subject norm – the social pressure to perform or not to perform the behaviour

(Zint, 2002).

According to Miller and Khera (2010), attitudes were the sum of beliefs of a person about a particular behaviour weighted by the outcome evaluations of these beliefs, whereas subjective norms described how the social environment or significant others influence the person of interest, and behavioural intentions were measures that could be used to predict whether people would be performing some actual behaviour.

The theory assumed that all other factors affecting intention are regarded as exercising their influence through AB and SN. Hence, it is summarized using Figure 2.3 below.

Figure 2.3 A summary of the Theory of Reasoned Action

The theory of reasoned action could also be expressed using the following function (Hale, 2003):

\[ BI = w_1 \times AB + w_2 \times SN \]

Key:

- BI = behavioural intention
- AB = one’s attitude toward performing the behaviour

34
\[ w = \text{empirically derived weights} \]

SN = a person’s subjective norm related to performing the behaviour

Zin: (2002) summarized a number of research findings, including results of a number of meta-analyses, on TRA (p.824) and argued the theory as valid and reliable. Nevertheless, the researcher also clearly pointed out that the TRA is limited in predicting behaviour over which individuals have volitional controls (p.827). In schools, though teachers have a certain degree of freedom, the TRA is believed to have limited validity as the “chain of command” can significantly affect teachers’ actions. Furthermore, factors like school vision and missions, funding available, peer pressure from colleagues, pedagogical content knowledge, etc. can affect teachers’ intentions to act and eventually their behaviours in classrooms.

2.6 Theory of planned behaviour (TPB)

Despite the TRA appearing to be plausible, it was not difficult to find counter examples in which attitudes and subjective norms could not successfully predict behavioural intentions. There might be a number of circumstantial limitations, which were not related to attitudes or subjective norms, but which could influence a person’s behavioural intention. To deal with such situations, Ajzen and Fishbein extended the TRA by including another construct: perceived behaviour control (PBC). According to Ajzen (1985), PBC refers to a person’s perceived ease or difficulty in performing a particular behaviour. More specifically speaking, the PEC could be elaborated as whether one believed he or she could control the behaviour and had the resources like time and money required for performing the behaviour. The two components of PBC were also called self-efficacy (Bandura, 1996) and perceived facilitation respectively.
The theory of planned behaviour (Ajzen, 1985) states that a person's action is determined by personal motivation, which in turn is determined by three determinants: attitude, social support, and perceived behavioural control. In addition, the determinants are shaped by the person's perceived personal, social, and situational consequences of the specified action.

To go into more detail, the theory suggests that the intent to act (BI) is the best predictor of behaviour (B). Furthermore, BI is determined by three constructs:

- **Attitude toward the behaviour (AB)** – the extent to which an individual believes the target behaviour will lead to desirable consequences
- **Subjective norm (SN)** – the extent to which an individual believes that others who are considered important to them think the behaviour should be performed
- **Perceived behavioural control (PBC)** – the person's beliefs about the behaviour's difficulty or easiness with reference to some external (e.g. time and money) and some internal factors (e.g. knowledge and ability)

![Diagram](image)

**Figure 2.4 A summary of the Theory of Planned Behaviour**

The theory can also be summarized using the equation below.

\[
B \sim BI \sim (AB+SN+PBC) = w_1 \times AB + w_2 \times SN + w_3 \times PBC
\]

* \(w_1, w_2\) and \(w_3\) represent the relative contributions of the three constructs.

When comparing TRA and TPB, the later is more consistent with Bandura's theory of self-efficacy (Bandura, 1996). Bandura described the psychological factor "self-efficacy" as
an individual's beliefs and expectations of his/her capability to perform a task. There were quite a number of researchers like Lane, Lane and Kyprianou (2004) demonstrated that self-efficacy can be used to predict learners' academic performance in conventional learning environments. Similarly, teacher self-efficacy has been researched for a long time because it affects teaching performance and student learning (Ho & Hau, 2004; Labone, 2004)

Ajzen built on the construct self-efficacy and adopted the term perceived behaviour control. Thus, it is reasonable to argue TPB is superior to TRA as an attitude-behaviour theory.

According to Ballone and Czerniak (2001, p.9), Ajzen's (1985) theory of planned behaviour has been widely used in science education research to predict an individual's intention to participate in a specified behaviour. In other words, it is possible to argue that the TPB has been shown to be instrumental in identifying belief-based factors influencing behaviour and intention. The theory is particularly suitable for research on the effects of science teacher beliefs have on an innovation.

As outlined above, the theory of planned behaviour should provide a more subtle insight into the relationship between belief and behaviour when compared with the theory of reasoned action. The theory had been used in many studies. On the critical point of view, the theory was not easy to comprehend as the three constructs mentioned were abstract. With the effort of Taylor and Todd (1995), the theory or rather the belief structure was deconstructed into a more elaborated one. Firstly, the construct attitude was divided into three antecedent factors suggested by Rogers (2003): "relative advantages (Ra)", "complexity (Cpx)" and "compatibility (Cpa)". The subjective norm was related to "normative influences (NormInf)", and the perceived behavioural control (PBC) was decomposed into "efficacy (Eff)" and "facilitating conditions (FacCon)". The purpose of
the deconstruction is to bring the theory a step closer to providing many beginning or even experienced researchers with an easy to understand conceptual framework for beliefs.

Taylor and Todd (1995) further suggest that on the one hand PBC in the theory had influence on behaviour by changing behavioural intention, and on the other hand that PBC could have a direct effect on behaviour.

The following diagram depicted the deconstructed theory of planned behaviour.

![Diagram of the Deconstructed Theory of Planned Behaviour](image)

Figure 2.5 A summary of the Deconstructed Theory of Planned Behaviour

2.7 Theory of trying (TT)

The theory of trying (Bagozzi & Warshaw, 1990) built on Ajzen theory of planned behaviour. The theory argues that there are a number of factors that affect intention to act, and a person's behaviour can be predicted from his/her intention to act. Furthermore, the theory states that there are three different attitude constructs: attitude toward success (A_s), attitude toward failure (A_f) and attitude toward process (A_p). Furthermore, attitude toward success would be mediated by expectation of success (E_s) and attitude toward failure would be mediated by expectation of failure (E_f). Last but not the least, the theory propose that past behaviour (PB), defined in terms of frequency and recency, has a direct effect on intention to act and behaviour (Zint, 2002, p.829).
However, at this stage of the literature review, the amount of research on science teachers using the Theory of Planned Behaviour far exceeds that of the Theory of Trying. It will be interesting to explore why the reason behind the phenomenon. For this study, it was decided that there is no need to pursue the details of the Theory of Trying.

2.8 Technology acceptance model (TAM)

Davis (1989) put forward the “Technology Acceptance Model”, an adaptation of the widely studied Theory of Reasoned Action (TRA), and argued that perceived usefulness (PU) and perceived ease of use (PEoU) are good determinants of user acceptance of an IT system. The TAM was regarded as firmly rooted in social psychology theories and provides parsimoniously, empirically proven valid and reliable generic tools for predicting technology use. According to Davis (1989), PU is “the degree to which a person believes that using a particular system would enhance his or her job performance”; while PEoU is “the degree to which a person believes that using a particular system would be free of effort”. Moreover, Davis claimed that an IT system perceived to be easier to use than another is more likely to be accepted by users, and he hypothesized and subsequently confirmed in a report published in 1989 that PU and PEoU are two distinct determinants for user acceptance of IT systems like "Chart-Master". He also argued that PEoU is a causal antecedent to PU, rather than a parallel, and consequently it is a direct determinant of IT system usage. The TAM is depicted in Figure 2.7.
Figure 2.7  The theoretical framework of the TAM

After more than a decade, it is reasonable to raise the question as to whether TAM is applicable now, especially in the rapidly changing arena of information technology. However, the TAM was built on a foundation of theories such as the Self-Efficacy Theory, the Cost-Benefit Paradigm, Adoption of Innovations, the Channel Disposition Model, etc. (Davis, 1989; p.321-322), together with numerous empirical studies, the model developed has its own strengths (Davis, 1993; Taylor & Todd, 1995; Agarwal & Prasad, 1998; Vankatesh & Davis, 2000; Matheison, Peacock & Chin, 2001; Brown, 2002; Yuen & Ma, 2004; Miller & Khera, 2010). In addition, the study by Davis (1989) produced two simple yet valid and reliable instruments for measuring PU and PEoU. The said instruments had "highly convergent, discriminant, and factorial validity", as well as very high reliability, and were highly correlated with current and future usage (Table 2.3). Hence, this study adopted the TAM as the working model.

Table 2.3  Characteristics of the instruments for measuring PU and PEoU (Davis, Bagozzi & Warshaw, 1989)

<table>
<thead>
<tr>
<th>Items in the scale</th>
<th>Cronbach alpha</th>
<th>Correlation with &quot;current usage&quot;</th>
<th>Correlation with &quot;future usage&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU</td>
<td>6</td>
<td>0.98</td>
<td>0.63</td>
</tr>
<tr>
<td>PEoU</td>
<td>6</td>
<td>0.94</td>
<td>0.45</td>
</tr>
</tbody>
</table>
In this study, the two instruments developed by Davis have been adopted and used to gather teachers’ beliefs about ICT (Appendix C). Furthermore, the instruments were modified to use the generic term “information technology” instead of a specific IT application system (Davis, 1989; p.340).

2.9 Motivation and personal agency beliefs theory

Ford (1992) argued that people context beliefs and capability beliefs can be very good predictors of people’s action. Context beliefs were evaluations of whether one has the responsive environment needed to support effective functioning whereas capability beliefs were evaluations of whether one has the personal skill needed to function effectively. Ford summarized his theory as follows.

\[
\text{Achievement/Competence} = \text{Motivation} \times \text{Skill} \times \text{Responsive Environment}
\]

In other words, people must also believe that they have the capabilities and opportunities needed to achieve their goals. Ford argued that such beliefs are often more fundamental than the actual skills and circumstances as people could be motivated to create opportunities and acquire capabilities they did not yet possess.

2.10 Context beliefs

Lumpe and Chambers (2001) published their research using the title “Assessing Teachers’ Context Beliefs about Technology Use”. They attempted to develop an instrument for assessing teachers’ context beliefs about using technology in the classroom. In addition, they also tried to validate the instrument so developed using a reasonably large sample of teachers.

Lumpe and Chambers approached the first target by consulting Ford’s Motivation and Personal Agency Beliefs Theory and gathered opinions from 20 teachers participating in
technology-related graduate studies. The product was an instrument called “Beliefs About Teaching with Technology” (BATT) with certain degree of content validity. The instrument has two sub-scales, ‘Enable’ and ‘Likelihood’. A total of 14 factors are included: resources, professional development, access to the Internet, quality software, physical classroom structures, support from administrators, support from parents, support from other teachers, technical support, planning time, student use time, class size, mobile equipment and proper connections.

Furthermore, the researchers argued "Capability Beliefs and Context Beliefs are significant predictors of teachers’ reported use of technology-related engaged learning practices". In addition, they firstly defined what beliefs are, and then they defined the two aforesaid beliefs very clearly. A summary of the researchers’ ideas on beliefs is presented in Table 2.4.

Table 2.4 Beliefs, capability beliefs and context beliefs proposed by Lumpe and Chambers

<table>
<thead>
<tr>
<th>Beliefs</th>
<th>Ideas people are committed to – sometimes called core values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Beliefs</td>
<td>Beliefs in one’s capacities to organize and execute the courses of action required to produce given attainments</td>
</tr>
<tr>
<td>Context Beliefs</td>
<td>Beliefs about the ability of external factors or people to enable a person to reach a goal plus the belief that a factor is likely to occur</td>
</tr>
</tbody>
</table>

The researchers assumed that the quantitative instrument BATT could accurately assess participants’ beliefs or attitudes. To the best of the researcher’s understanding of assessing beliefs and attitudes, this is a common practice. However, it is disappointing that the researchers did not mention alternative ways of completing the same task.
In the second part of the research by Lumpe and Chambers (2001), more than 300 teachers were used to test the instrument items in the BATT. As all the teachers participated in a large-scale technology development programme focused on the integration of technology with principles of engaged learning, it is fair to say technology literate participants were used to test the instrument. Perhaps the most important finding of this research was the quite high alpha coefficients for the Enable and Likelihood subscales (α = .89 and α = .86 respectively) and the BATT (α = .88). This suggested the reliability of the instrument to be quite high and it is useful for further research in the same area.

Another important aspect of Lumpe and Chambers' research was the deployment of Ford's theory. The researchers described that personal agency belief (PAB) patterns are the results of the combination of context and capability beliefs, which are the basis for the analysis of people's level of motivation towards goal attainment. Furthermore, the identification and evolvement of PAB patterns are important for motivating people toward meeting different goals. These patterns either stimulate or hinder people. An understanding of PAB patterns is the basis for predicting teachers' classroom actions. The researchers also suggested that some teachers need professional development to stretch their capability, while other teachers need professional development on building up confidence for creating favourable contexts.

Another finding that is worth some discussion is the low correlation of the context belief measured by the BATT and the self-efficacy measured by another instrument: "The Microcomputer Utilization in Teaching Efficacy Beliefs Instrument (MUTEBI)". The low correlation coefficients clearly demonstrated that the Ford’s construct of context belief and the Bandura’s construct of self-efficacy (Bandura, 1996) is not only dissimilar in theory, and
also in practice, at least in this research. This suggests the further research in the use of technology in education should address the two constructs independently.

As an afterthought, the instrument BATT will be highly relevant and useful to this research on teachers' beliefs about ICT. The most important reason is the process of developing and validating of the BATT is systematic and the instrument is creditable. Furthermore, the suggestions made by the researchers on the possible use of the BATT are also valid and hence they are reproduced here.

The BATT can be used to
1. determine teachers' perceived need for professional development,
2. assess the perceived strengths and weaknesses of school technology programmes,
3. gauge the effect of a professional development programme,
4. develop profiles of teachers' PAB (Ford's theory), and
5. track over time to determine the factors that cause teachers to develop their beliefs about teaching with technology.

(Lumpe & Chambers, 2001)

2.11 Evaluation of ITED initiatives in Hong Kong

The Hong Kong SAR government launched the first phase of Information Technology in Education (ITED) initiatives from 1998 to 2003. The initiatives included numerous measures organized into the following themes:

a. Access, connectivity and usage,
b. Teacher enablement,
c. Curriculum, pedagogy and resources, and
d. School & wider community culture.

The report, "Overall Study on Reviewing the Progress and Evaluating The Information Technology in Education (ITED) Projects 1998/2003" (EMB, 2005), depicted a cross-sectional
view of the final stage of the ITEd initiatives (hereafter, the report will be referred as "ITEd report"). Put another way, the ITEd report described the most current scenarios of the implementation of IT in education in Hong Kong after the completion of the first phase of ITEd initiatives.

The study gathered data by a combination of quantitative and qualitative methods. Quantitative methods used were questionnaire surveys, IT literacy assessment and IT activity daily log. Qualitative methods used were observations, focus group and individual interviews, and document analysis. It is possible to argue that the diverse methods used in the study should provide a set of relevant, rich data related to the implementation of IT in education in Hong Kong. Also, it is not an odd idea that the study should provide examples of unique uses of ICT in education. Furthermore, the diverse methods adopted should enable triangulation of data so gathered to be done with ease.

The study (EMB, 2005) is impressive when evaluated from the number of schools, school heads, IT team members, teachers, students and other stakeholders who participated. The following list illustrates various aspects related to how quantitative data were gathered from the secondary school sector:

<table>
<thead>
<tr>
<th>Data source</th>
<th>Instrument</th>
<th>n</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schools</td>
<td>School Information Technology Survey Form</td>
<td>378</td>
<td>92%</td>
</tr>
<tr>
<td>School Heads</td>
<td>School Heads' Questionnaire</td>
<td>372</td>
<td>90%</td>
</tr>
<tr>
<td>IT Team Members</td>
<td>IT Team Members' Questionnaire</td>
<td>668</td>
<td>91%</td>
</tr>
<tr>
<td>Teachers</td>
<td>Teachers' Questionnaire</td>
<td>6,497</td>
<td>91%</td>
</tr>
<tr>
<td>Students</td>
<td>Students' Questionnaire</td>
<td>5,943</td>
<td>92%</td>
</tr>
</tbody>
</table>

* from a total 125 secondary schools selected through stratified sampling
Besides the aforesaid data sources, 21 secondary schools were selected for further in-depth study, which included a school tour, classroom observations, school document analyses, IT literacy assessment and IT activity daily log for students, and parents' questionnaire. Lastly, data gathering methodologies like individual or focus group interviews were used with diverse stakeholders. The following is the list of stakeholders who participated in the interviews.

- School heads, teachers and students
- Representatives from trade associations, school sponsoring bodies, tertiary education institutes, non-government organisations (NGOs) with parent education services
- ITEd project officers and policy makers/directorates.

With the numerous means to gather and the diverse sources of data, the study should produce a set of data for describing the status of the ITEd initiatives. In a nutshell, the study was a comprehensive research in ITEd done locally and the ITEd report described the holistic picture of information technology in education in Hong Kong.

Having described the data gathering methods and the data sources, the study findings should be reported. On the theme “Access, Connectivity and Usage”, the ITEd report described the number of computers and other hardware in secondary schools have far exceeded targets, for instance, an average of 237 computers are available in a secondary school; all schools have the Internet connection with 97.6% secondary schools having broadband connection; and a ratio of 4.6 students per computer has been attained. Nevertheless, there are some major aspects like “not every individual classroom has network connection” and “the number of computers located in general classrooms is still relative low, only 10.5 per secondary school”, i.e. less than 50% of general classrooms have computers installed. The report argued that this might create a barrier to more integrated use of IT across subject curricula. Though the said percentage was not disappointingly low, teachers
may find it not encouraging to bring along a number of equipment including a portable computer, a LCD projector and a number of accessories to a general classroom for the conduction of a lesson with ICT.

The evidences related to the theme "Teacher Enablement" listed in the ITED report were paradoxical. First of all, the report described the facts that all teachers who responded reported they have completed at least a basic level of IT competency, and 89.3% secondary school teachers have reached intermediate or above level of IT competency. With reference to these figures, teachers should have sound IT competency. Alongside with the high "teacher IT competency level" reported, the ITED report also described that only 54.1%-68.7% teachers rated themselves proficient in applying/integrating IT into their subject curricula. At the even more extreme end of the spectrum, there were still 15.7%-28.2% of teachers who regarded themselves non-users, novices or beginners in adopting IT in teaching. Teachers' perceptions of their own competency levels are quite different from their self-reported IT competency levels. In another key aspect related to "Teacher Enablement", teachers reported that they need less training with regard to technical expertise, and prefer various parties more focus their professional development on effective pedagogical use of IT and sharing of experiences with subject-based colleagues. Hence, it is possible to suggest that teachers are willing to use IT in their lessons, however, they need more training in IT-based pedagogical knowledge in their subject disciplines.

There is an important finding in the ITED report, 76.8% to 87.3% of teachers reported they experience restrictions in incorporating IT into their teaching imposed by two factors: insufficient time and excessive workload, and pressures of the public examination-driven system; i.e. barriers that are so general that they hinder any changes to be institutionalized in any school. Lastly, teachers mentioned ongoing technical support as well as support in locating and evaluating suitable teaching software as the utmost important.
On the theme "Curriculum, Pedagogy and Resources" the report mentioned that there is clear evidence that teachers are using IT for searching for information and preparing notes/course materials for teaching purposes. It is possible to say that teachers are using IT as a tool (Taylor, 1980) to facilitate the completion of their teaching-related tasks. As there are no alternatives to the use of IT-based tools like word processing software, and the Internet is a rich database of resource materials, teachers have to use IT for preparing notes/course materials nowadays, despite some teachers may not prefer the use of such technology. According to the school heads who participated in the study, the IT usage in the science education key learning area (KLA) amounts to 98.7%, which indeed is a very high figure. However, it is necessary to deliberate on whether the figure reflects the status of use at the classroom level. The report also mentioned that most of the reported IT use is “by teachers”, and students received some degree of encouragement or request from teachers to perform a variety of learning-related tasks with IT. Hence, it is possible to state that the level of use of IT in classrooms is still best described as in an infant or early childhood stage.

The report described that teachers’ pedagogical use of IT has been found to be related to several factors: “school IT resources and support”, “teachers’ own IT beliefs and competence”, and, to a much lesser extent, “school heads’ beliefs and school IT culture”. Given the fact that this research attempts to solicit how teachers’ beliefs are related to their uses of ICT in their classrooms, the aforementioned findings are strong justifications for the significance of this study – a more in-depth analysis of a strand of the science subjects and a sub-group of teachers is needed.
On the mode of use, the report stated explicitly:

actual classroom use of IT is still more related to teacher-centred rather than student-centred learning, involving predominantly didactic expository teaching ... relatively less opportunity for individual interaction with computers and even less for collaborative interaction focussing on facilitating learning and assessment or for tasks requiring high-order thinking skills (EMB, 2005).

In short, there is only very limited evidence on paradigm shift (ED, 1998), except a significant proportion of teachers reported having encouraged or requested students to use IT for self-learning and engaging in collaborative projects outside classes.

On the theme "School and wider community culture", the report suggested that "there seems to be a growing culture of use of IT by school heads, teachers, specialists/therapists and students both in school and outside school, and parents in general are supportive of ITEd ... most school heads reported a positive impact of IT on school administration and management ...". However, whether IT has a positive impact on teaching and learning has not been outlined in the report.

On the theme "student learning", the report presented the following key evidences:

• Student use of IT at home is much higher than their use in school, they used IT mainly for entertainment and searching information outside school; but also for learning-related work.

• There is a pattern of decreasing use of IT in school for upper-level secondary students.

• The majority of students have developed confidence in using IT, with fewer than 20% of respondents indicating that they feel not quite confident or not confident at all.
Before the close of this section, it is imperative to leave a remark that the study outlined was conducted by ICT in education experts from a local university with the funding from the now Education Bureau of the Hong Kong SAR Government. Readers need to scrutinize the objectivity of the report in a vigilant way.

2.12 Theoretical framework

The social cognitive theories advocate that human behaviour is a triadic, dynamic, and reciprocal interaction of personal factors, behaviour and the environment. The theories are pertinent to the proposed study, why and why teachers does not integrate ICT in teaching and learning. Factors like self-efficacy, contextual beliefs and attempted ICT-based teaching and learning practices have to be examined in order to reveal some implicit factors that can either facilitate or hinder the change expected, i.e. to extend the scope and depth of the use of ICT for teaching and learning.

As mentioned previously in Chapter 1 and explained in this chapter, data related to the three personal beliefs constructs (i.e. PU, PEoU and CONTX) and the self-reported use of ICT in teaching and learning will be used. From the literature reviewed, it is found that CONTX affects PEoU, and PEoU affects PU. In addition, it is hypothesized that the three beliefs constructs will have influence on the ICT usage, and other mediating factors such as what Ertmer (1999) refers to as extrinsic barriers are not significant in this study with due regard to the local context. Furthermore, this study also assumes that teacher self-reported ICT usage for teaching and learning predicts their actual use in classrooms, and the data gathered from the sample (i.e. chemistry teachers) can help to create a rough portrayal of the actual scenario on how chemistry teachers use ICT in their classrooms. The following concept map is used to depict the said relationships and assumptions made.
Self-reported use of ICT-based tools for teaching and learning

Actual use of ICT for teaching and learning

Figure 2.8  The theoretical framework of this study
3. Methodology

3.1 Introduction

McCall (1998) states that “Good research is not accidental ... it requires careful planning as well as careful execution”. In other words, valid and reliable data can be obtained if a good design is in place at the early stage of a study and the design is implemented with caution. Among all the different stages of a research project, it is very important to select the most appropriate data collection methodology. Furthermore, though it appears to somewhat be stating the obvious, it is imperative here to argue that the data collection methods to be used have to be carefully aligned with the overall aims and purposes of the research. Having said that, it is the purpose of this chapter to describe the data collection methods to be used and put forward the arguments for using them. In addition, the implications of the "paradigm wars" (Erlandson, Harris, Skipper & Allen, 1993) on the methodology of this research will be presented. Towards the end of this chapter, a discussion on and the means adopted to deal with potential ethical problems and limitations related to this research will also be presented.

Divisive views on how to inquire into the issues or problems in the educational arena are found in the research community, and in fact the huge debate between the two main research methodologies has yet to come to an end. Some authors categorized qualitative and quantitative research as two distinct and opposed approaches. For instance, Patton (1990) described two competing research methodologies as “logical-positivism” and “phenomenological inquiry”. The logical-positivism methodology uses “quantitative and experimental methods to test hypothetical-deductive generalizations” and has positivism as the dominant worldview. This approach is commonly adopted in the physical sciences or medical researches. On the other hand, the phenomenological inquiry methodology uses
"qualitative and naturalistic approaches to inductively and holistically understand human experience in context-specific settings" (p.37). The researchers in this camp treasure subjective, culture-bound and emancipatory approach to studying individual behaviours and social phenomena (Tashakkori & Teddlie, 2003). The approach is often adopted by researchers in social sciences.

Borg and Gall (1989) put forward two approaches: positivistic and naturalistic. They suggested that the two approaches differ in a number of dimensions on top of the nature of data to be gathered. The two approaches differ in the following dimensions.

- the vision of the nature of reality,
- the relationship of the researcher to the research participants,
- issues of generalizability,
- discussion of causality, and
- the role of values.

Carr and Kemmis (cited in Merriam, 1998) suggested that there are three basic forms of educational research – positivist, interpretative and critical. The positivist form of research, education or a school is considered as an object, phenomenon, or delivery system to be studied. Knowledge gained through scientific and experimental research is objective and quantifiable. The findings from this type of research are stable, observable, measurable and often can be generalized. With the interpretative research, education is considered to be a process and a school is a live experience. An inductive approach should be employed to understand the meaning of the process and experience. Multiple realities are constructed socially by individuals. The critical research, a school is considered to be a social institution designed for social and cultural reproduction and transformation. This type of research produces knowledge like ideological critique of power, privilege, and oppression in the areas of educational practice.
It is necessary to argue here, there is no genuine need to divide the two approaches (positivist and interpretative) as distinct ones and treats them as being mutually exclusive. Rather, it is recently becoming more common in the literature that they are used together to supplement and complement each other. As an example, Zhang (2001) argued

"In general, the tendency to suggest a compromise can be seen in the emerging literature which advocates for complementarily and compatibility rather than a divorce between the two. Theorists are also asking for actual research to use both methods."

In a similar way, Tashakkori and Teddlie (2003) put forward the term "third methodological movement" and elaborate as follows.

"The field of mixed methodology, which we call the "third methodological movement", has evolved as a result of these discussions (positivist and interpretative approaches) and controversies and as a pragmatic way of using the strengths of both approaches.

In order to scrutinize how chemistry teacher beliefs are related to their ICT-based practices, this is a research using two research approaches: the positivist as well as the interpretative. More specifically, a number of variables like teacher beliefs about teaching and learning, perceived usefulness of ICT and ease of using ICT will be gauged by a survey, and then correlated with the uses of ICT-based teaching and learning practices. After that, some focus group meetings or face-to-face interviews will be arranged to solicit information on how teachers use of ICT-based practices and their views of ICT. It is argued that teacher beliefs can be deduced using the said data collection methods.

In this study, a dominant-less dominant design (Lee, 1998; Creswell, 2003; Tashakkori & Teddlie, 2003; Gifford, 2004) has been adopted. Put it another way, this study is
essentially quantitative in nature, but a small qualitative component is incorporated. The purpose of using the dominant-less dominant design in this study is two-fold: to develop a holistic understanding of how the majority of chemistry teachers use and believe in the ICT-based tools for teaching and learning, and to develop an in-depth knowledge of why a number of teachers with different background differ in the aforementioned beliefs. It can be said the use of the design is building on the unique strengths of the quantitative design and at the same time capitalizing on the attributes of the qualitative one (Lee, 1998). With careful execution of the data collection methods adopted in this study, the validity and reliability of data collected should not be a great concern for researchers in both the quantitative and the qualitative camps.

3.2 Sampling

The subjects of this study are in-service chemistry teachers in Hong Kong SAR. As the Education Bureau or the former Education Department of the Hong Kong SAR government has a very firm requirement for working as a chemistry teacher in Hong Kong so as to maintain school laboratory safety standard, all chemistry teachers have to be subject-trained, i.e. chemistry teachers in Hong Kong must be majoring in chemistry or biochemistry in their undergraduate study since the early 1990s (Appendix H). It is reasonable to argue that chemistry teachers belong to a homogeneous population.

With consideration of the fact that the major Hong Kong economic downturn starting late twentieth century, the local job market including teaching profession is quite stagnant, the wastage rates of trained teachers are 5.1% in both 2004/2005 and 2005/2006, and 5.8% and 5.5% in 2007/2008 and 2008/2009 academic years respectively (EDB, 2009a), it is reasonable to argue that the majority of chemistry teachers with IT training remained in the profession.
As the formal statistics on the number of chemistry teachers in Hong Kong cannot be located, the population in this study is estimated using the method outline below. According to Education and Manpower Bureau statistics in 2008/2009 school year (EDB, 2009a), there are about 503 local secondary schools in Hong Kong. According to the researcher's understanding of the field, it is known that nearly all secondary schools offer chemistry courses at Secondary 4-5, Advanced Supplementary Level or Advanced Level, and in most cases that each school will have two chemistry teachers, it is estimated that there are about 1000 chemistry teachers in Hong Kong. As the study aims to provide a holistic picture of using ICT-based learning and teaching activities in Hong Kong, a representative sample should be collected. Accordingly, the study will include 278 secondary school chemistry teachers as the subjects so as to achieve a 95% confidence level at a 5% confidence interval (Sample Size Calculator, 2008).

3.3 Quantitative component – the survey

To answer the research questions, it is necessary to gather from the subjects' information like demographic data, teachers' use of ICT-based teaching and learning tools and teachers' beliefs. In the local schools, teachers are very busy people as they have to deliver around twenty five 40-minutes lessons per week to classes with about 40 students, to mark course work, to handle numerous administrative duties, to provide guidance to students, to attend professional development courses, etc.. With numerous teaching and non-teaching related tasks, teachers are very likely to ignore requests to complete a survey, or at best they will respond to a brief research instrument that can be completed in a short period of time. Hence, a carefully designed precise and concise questionnaire will be needed. The use of self-addressed stamped return envelopes may also help to increase the return rate. However, incentives such as small gifts would not be used as the practice may induce invalid responses from the subjects.
Use a survey has an advantage that a large number of subjects can be approached and hence can provide information that can be used to create a broad-brush picture of a phenomenon. In other words, a questionnaire can gather information efficiently by using only a moderate amount of resource, and this fits nicely into this small scale resource limited study. The most important reason of using a questionnaire to solicit required information is the congruence between the nature of the questionnaire and one of the research goal: What kinds of ICT-based teaching and learning tools are teachers using? If the interpretative approach is to be used, it is anticipated that a very significant investment of resources, including but not limited to manpower and time, has to be deployed. Given the timeframe limitation, a positivist approach will be used in the first phase of this study, while an interpretative approach will be used as a supplement in the next phase.

Development and pilot testing of survey instrument

With reference to the theoretical framework describe in Chapter 2, and a detailed review of various instruments used for soliciting teachers’ beliefs about the use of ICT for teaching and learning (Table 3.1), a pilot questionnaire was developed for this study. Even though local chemistry teachers have a good mastery of English language, all the questions used in the questionnaire were written in plain and direct English. The said practice enhances the accuracy of communication between the researcher and the subjects. The major components of the instrument described below:

a. Demographic data.

b. Frequency of use of ICT tools for teaching and learning.

c. Perceived usefulness and perceived ease of use of ICT tools – modified from the instrument “Measurement Scales for Perceived Usefulness and Relative Ease of Use” developed by Davis (1989).
d. Contextual belief about teaching with technology - modified from the instrument “Beliefs about Teaching with Technology (BATT)” developed by Lumpe and Chambers (2001).

Table 3.1 Instruments used by various researchers to solicit information related to teachers’ use of technology and beliefs about technology

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Authors and year of publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Attribute Survey</td>
<td>Vannatta and Fordham, 2004, p.266</td>
</tr>
<tr>
<td>Teachers’ Class Use of Computers</td>
<td>van Braak, 2001, p.153</td>
</tr>
<tr>
<td>Beliefs About Teaching with Technology (BATT)</td>
<td>Lumpe and Chambers, 2001</td>
</tr>
<tr>
<td>and Perceived Ease of Use (PEoU)</td>
<td></td>
</tr>
<tr>
<td>Levels of Technology Implementation (LoTi) Questionnaire</td>
<td>Moersch, 1995</td>
</tr>
<tr>
<td>Questionnaire: Teachers’ decisions to adopt new technology</td>
<td>Sugar, Crawley and Fine, 2004</td>
</tr>
<tr>
<td>Questionnaire: Nature and extent of cyberphobia</td>
<td>Russell and Bradley, 1997</td>
</tr>
<tr>
<td>Teacher Locus of Control (TLC) Scale</td>
<td>Marcinkiewicz, 1994</td>
</tr>
</tbody>
</table>

The pilot test was conducted with four experienced chemistry teachers. They were invited to complete the questionnaire, to estimate the time required for completion, to return the questionnaire by mail, and to put forward their comments by phone. It was reported by all participants that they took much less than fifteen minutes to complete the questionnaire. Respondents in the pilot test did welcome the provision of a stamp self-addressed envelope. One participant in the pilot test suggested an amendment to the questionnaire by including an additional ICT based tool “ChemSense”, and the suggestion was adopted. Another participant suggested putting the section for gathering demographic data to the rear part of the instrument so that respondents can focus on the themes of study. The suggestion was also adopted. After making the adjustments, the final version of the questionnaire with four different sections was developed. Please refer to Appendix C for details of the finalized survey questionnaire.
Section A of the survey questionnaire – Frequency of Use (ICT_usage)

Respondents were requested to indicate their frequencies of use of ICT for teaching and learning. First of all, fourteen different ICT tools were included in the instrument. It is worth mentioning that the use of web browsers was not included as these tools should be very widely used by teachers, and would be less likely to generate useful information. Hence, the tools included in this study are

- Word processing, Spreadsheet, Presentation;
- Animation, Drill and Practice, Tutorial, Multimedia Package;
- Simulation, Data-logging System;
- Webquest, ChemSense, e-Group, Knowledge Forum; and
- Authorware.

To gather information about the frequency of use of each of these tools per year, a discontinuous but progressive scale was used. The scale was as follows:

NIL=1; 1-2 times=2; 3-5 times=3; 6-10 times=4; more than 10 times=5

The total score or ICT_usage will then be reckoned by simple summation. A low ICT_usage value suggests that the participant is a low level ICT user, and a high ICT_usage value indicates the opposite.

Section B of the survey questionnaire – “Measurement Scales for Perceived Usefulness and Relative Ease of Use” (PU and PEoU)

Davis (1989) put forward the “Technology Acceptance Model” for the examination of whether computer users thought a specific ICT tool would be useful and easy to use. He conducted two validation studies so as to develop two scales according to the principle of parsimony for measuring PU and PEoU. The first study made use of two ICT tools operated in IBM mainframe systems: PROFS (electronic mail) and XEDIT (file editor) (p.326). The second study made use of another two ICT tools operated in PC based systems:
Chart-Master and Pen-draw (both were graphics systems) (p.330). Davis (1989) reported that the two scales exhibited excellent psychometric characteristics as follows:

Convergent and discriminant validity were strongly supported by multitrait-multimethod analyses in both validation studies. These two data sets also provided strong support for factorial validity: the pattern of factor loadings confirmed that a priori structure of the two instruments, with usefulness items loading highly on one factor, ease of use items loading highly on the other factor, and small cross-factor loadings (p. 333).

Also based on the two validation studies, Davis (1989, p.333) reported the scale for measuring PU and PEOU had very high alpha coefficients, $\alpha=.98$ and $\alpha=.94$ respectively; and high correlation coefficients existed between the PU and self-report current use in the first study ($r=.63$), and between the PU and self-predicted future use in the second study ($r=.85$). For the PEOU, it was also correlated with the use in the two studies ($r=.45$ and $r=.69$ respectively).

As reported by Rose and Struab (1998), the TAM was widely used to examine PU and PEOU in different ICT tools.

Table 3.2 Computer technology tools examined in TAM based studies

<table>
<thead>
<tr>
<th>Study (cited in Rose &amp; Struab, 1998)</th>
<th>Computer Technology Examined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams, et al., 1992</td>
<td>E-mail, voice-mail, graphics, spreadsheet, word processing software</td>
</tr>
<tr>
<td>Karahanna, 1993</td>
<td>E-mail and voice-mail</td>
</tr>
<tr>
<td>Goette, 1995</td>
<td>Adaptive technology for the disabled</td>
</tr>
<tr>
<td>Hendrickson, et al., 1993</td>
<td>Spreadsheet and DBMS (data base management system)</td>
</tr>
<tr>
<td>Mathieson, 1991</td>
<td>Spreadsheet software</td>
</tr>
</tbody>
</table>
More recently, the TAM was used by Brown (2002), Yuen and Ma (2004), and also by Kao and Tsai (2009) to study the use of web-based learning technology. In addition, there were also studies intended to extend the TAM by including other attributes: Mathieson, Peacock and Chin (2001) attempted to include "Perceived User Resources" and Yuen and Ma (2004) tried to include "Intention to Use".

Given the fact that TAM was widely used in numerous studies and the high quality of the instrument for measuring PU and PEoU, this study will also made use of TAM. However, not all the attributes listed above were adopted. This study includes only PU and PEoU. Also, the statements for soliciting information of PU and PEoU on a specific ICT tool were changed to a general item "ICT". Furthermore, a discontinuous but progressive scale similar to the dependent variable ICT_usage was also used for PU and PEoU, i.e. the following scale was adopted in the questionnaire:

Very Likely=1; Somewhat Likely=2; Neutral=3; Somewhat Unlikely=4; Very Unlikely=5

The total score from the first set of six statements related usefulness would then be reckoned by simple summation to give a PU value. A low PU value suggests that the participant perceived ICT as useful, and a high PU indicates the opposite. The PEoU value would be determined in a similar manner.

Section C of the survey questionnaire – Beliefs About Teaching with Technology (BATT)

This part of the questionnaire makes use of the instrument development by Lumpe and Chambers (2001), which was intended to solicit data related to beliefs about teaching with technology. According to Lumpe and Chambers (2001), there are two distinct belief factors in BATT, enable beliefs and likelihood beliefs, as identified by the technique factor analysis (an inferential statistical technique). In addition, the BATT instrument was found to be reliable and valid for gathering data related to the said beliefs. The BATT instrument has a
high alpha coefficient $\alpha=0.88$ for the BATT entire score. Details of the two subscales in the BATT instrument are listed below.

a. Enabling Subscale: factors that would enable a person to be an effective teacher. The response to each of the question will be scored using the following scale:

Strongly Agree=1; Agree=2; Undecided=3; Disagree=4; Strongly Disagree=5

A low score on the "enabling" subscale suggests that those factors are believed to be important enabling agents, and a high score indicates the opposite.

b. Likelihood Subscale: how likely these factors will occur. The response to each of the question will be scored using the following scale:

Very Likely=1; Somewhat Likely=2; Neither=3; Somewhat Unlikely=4; Very Unlikely=5

A low score on the "likelihood" subscale suggests that those factors are believed to be likely to occur, and with a high score indicates the opposite.

Section D of the survey questionnaire – Demographic Data

This section attempted to gather demographic data of the respondents. To ensure the continuity of the use of the principle of parsimony in this study, only the most essential items required for the analysis were included in the survey questionnaire.

Personal data like gender, age group, highest education in science (chemistry) and in education, teaching experience, position in chemistry department, teaching level and ICT competency level etc. would be collected using separate items. Data related to participant's school like type of school, school district and student ability would also be collected. Still some more data like working hours after school and personal IT uses would be collected too. Details of the items used for gathering demographic data can be found in Section D of the questionnaire (Appendix C).
Data Analysis

In the data analysis, different belief constructs like PU, PEOU and CONTX would be analyzed against various demographic data. For instance, whether male and female teachers would have different beliefs about the use of ICT for teaching constructs would be analyzed with t-test; whether teachers with different ICT competency would be analyzed with ANOVA. In other cases, Pearson product moment correlation coefficients (r) would be computed to scrutinize the magnitudes and directions between the belief constructs. A common sense thinking may consider the constructs PU and PEOU would be related, hence the correlation coefficient of the two constructs would be computed in order to reveal whether they were related.

Administration of the survey questionnaire

Questionnaires were distributed to teachers directly in different professional development related activities and returned by mail or at the training venue. A total of three hundred questionnaires were handed out to teachers, and one hundred and twenty-two were returned. The return rate was 41%.

It was also noted that there were no queries from the respondents on the questionnaire by telephone or by email. It would be reasonable to postulate that the design of the questionnaire was fine and the respondents could complete the questionnaire without difficulties.
3.4 Qualitative component – the interviews

Perhaps the most obvious reason for using interpretative or qualitative approach in education research is related to the problems of setting up an experimental study environment in a school. It is not possible to use a research methodology that interferes with the processes of teaching and learning in a school without invoking salient ethical issues, criticisms or complaints from parents and teachers. Furthermore, just like other social researches, a research on teachers or students is preferably being done in a natural setting. Alternatively speaking, a study of the phenomenon in a school is better done in an environment in which everything is happening as usual. Artificial arrangements for research purposes are very likely to upset the truth out there (Hawthorne effect or novelty effect). A pragmatic way to study a school is to use research methodology like observation, interview or document analysis (Wiersma & Jurs, 2004). Further, the issue of validity is resolved, at least partly, with a qualitative research design.

This study is designed to develop an understanding about implicit beliefs held by the subjects. It is necessary to have an opportunity for researchers to meet subjects face-to-face and have sufficient time for dialogue. In addition, as subjects may embrace multiple realities, discussion can facilitate people to construct in a social environment. Thus, it is suggested that some qualitative data collection methods like focus group meetings or face-to-face interviews can be used in this study.

This study attempts to solicit the exact meaning of ICT usage in school context, and it definitely requires a methodology that is sensitive to underlying meaning and beliefs held by the subjects. The best research instrument that fits the aforesaid requirements, therefore, is a well-trained researcher with a very good understanding of the rationale of the study, research questions involved and what kinds of data are to be collected (Merriam, 1998). All
in all, qualitative data like teacher beliefs and their use of ICT will be gathered by a guided interview, i.e. a protocol will be used.

The qualitative instrument or the interview protocol (Appendix E) used in this study is the key aspect of the less-dominant design. The interview protocol should provide information so that data gathered from the survey instrument can be more thoroughly understood, as well as to solicit some additional data.

It is well known that closed-ended questions in the survey instrument (Appendix C) did not allow respondents to explain their choices; however, the qualitative instrument did encourage respondents to explain their practices and what they believe about ICT for teaching and learning through a face-to-face dialogue. Furthermore, with careful observation and accurate recording, interviews could be used to gather data related to emotions and passion, both positive and negative, towards the use of ICT-based tools for the teaching and learning of chemistry. This is particularly important as emotions and passion towards something can hardly be recorded using a self-response text-based survey instrument. In short, properly conducted interviews can drive chemistry teachers to reflect deeply about their beliefs toward the use of ICT-based instruments, and how exactly the ICT-based tools are used for teaching and learning.

Descriptive narrations gathered from interviews are then compared and contrasted with a view to establish patterns related to the use of ICT-based tools and teachers' beliefs about ICT for teaching and learning. As suggested by Miles and Huberman (1994), data reduction, data displays and conclusions drawing / verification are interactive data analysis processes that can be carried out during as well as after data collection processes. For this study, all data collected from interviews will be analyzed as suggested by Miles and Huberman (1994).
As an example, if two or more teachers reported in the interviews that their respective schools provided sufficient hardware for them as an encouragement to the use of ICT for teaching and learning, the said interview records will then be reduced and displayed as "hardware provided to encourage ICT usage". After that, the researcher can then argue that at least some of the first order barriers (Ertmer, 2005) have been removed, at least for the schools being studied. In short, only brief description about and conclusion of different themes will be presented in this thesis so as to enhance the readability.

3.5 Ethics considerations

According to Merriam (1998), there are professional codes and (US) federal regulations that deal with issues common to all social science researches – the protection of subjects from harm, the right to privacy, the notion of informed consent and the issue of deception. She further put forward the idea that it will be problematic when using these codes and regulations in qualitative research. Nevertheless, the codes and regulations are regarded as useful guidelines for this study for dealing with some potential ethical issues.

First of all, the subjects in this study were adults and it is unlikely they would be harmed by filling in a questionnaire or by being interviewed. Furthermore, issues related to the study of minors would not be relevant to this study, as all the respondents are secondary school chemistry teachers. Secondly, the questionnaire was used to gather quantitative data like use of ICT for teaching and learning, no questions in the instrument require the subjects to provide any sensitive personal information. In addition, all returned questionnaires would be identified by serial numbers only, in other words, there would be no way to identify respondents. In interview, all information provided by the respondents will be identified by pseudonyms only. Thirdly, the notion of informed consent has been dealt with in the design stage. In addition, the questionnaire and the interview invitation have been bundled
with a cover letter (Appendix B and D) stating the purpose of the study, statements like "you are under no obligation to participate in this research" and "your views and comments provided will be recorded anonymously" are included. Together with strict adherence to the general privacy data handling principles (AARE, 2009), the notion of informed consent should not be an issue in this research. Finally, the issue of deception is considered to be a very non-ethical means of obtaining data, which in no way will be approved by any research committee and is not a proper means to conduct research. For this research, all the data collection methods should be free from deception.

In the qualitative data collection process, only the researcher would be involved in the collection and analysis of the data. In addition, all the information reported by the respondents in this thesis will only be identified by pseudonyms. It is possible to say with confidence that all the information provided by respondents would not cause any ethical problems.

On data storage, only the researcher would have access to the information. Together with the adherence to the guideline that any information that may identify respondents will be deleted as soon as possible, this study should be free from ethical issues.
Cassell (1982, cited in Merriam, 1998, p. 213) suggested a continuum for analyzing risk and benefit in different types of research:

<table>
<thead>
<tr>
<th>Investigator has considerable power</th>
<th>Investigator has low power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomedical experimentation</td>
<td>Secondary analysis of data</td>
</tr>
<tr>
<td>Psychological experimentation</td>
<td></td>
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<tr>
<td>Face-to-face surveys</td>
<td></td>
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<tr>
<td>Mailed surveys</td>
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<td>Field or Nonreactive observation</td>
<td></td>
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<tr>
<td>studies</td>
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</table>

*Figure 3.1  A continuum for analyzing risk for different research methods*

Using the continuum as the basis of risk analysis for research, this study is using a questionnaire similar to "mailed survey" and "face-to-face survey", and hence should afford to the subjects only a medium to low level of risk. Together with the aforesaid measures to protect the subjects, this study should pose a low level of ethical problems to the subjects.

To further safeguard the subjects participated in this study from any possible harm, a formal ethics clearance application with all the details mentioned above was submitted, and a formal approval was awarded by the Ethical Committee of the researcher's institute.
3.6 Limitations and delimitations

Irrespective of the research paradigms adopted in a study, there are various limitations that cannot be easily resolved. According to Waller (2007), all research has inevitable limitations that may affect internal validity. For instance, although the survey questionnaire had been distributed for two months, the number of questionnaires returned was still less than desired. The researcher had to accept this and communicate the limitation: a mediocre response rate. In addition to response rate, the quality of the responses is equally or even more important. As an example, whether a participant is willing to provide actual or complete information is a potential threat to the internal validity. It is imperative for any researcher to consider all the potential factors that may compromise the validity and reliability of a study. In other words, it is important that the greatest effort should be spent to address all the potential limitations.

In this study, some limitations can be identified at the outset while some limitations are revealed as the study steps forward. Listed below are some of the limitations of this study.

- Generalizability: The respondents in this study are all chemistry teachers in Hong Kong, and hence the results have a hard to predict probability of being applicable to other subject teachers, or teachers working in geographically distinct cities.
- Instrument decay (Wallen, 2001) refers to problems associated with the alternation of the nature of the instrument in a deliberate or otherwise manner. For this study, the survey questionnaire use Likert scales, and the scoring procedure would be done with care. It is reasonable to say that instrument decay is not significant. For the interview, the researcher tried to read the questions in order to exercise the greatest control over instrument decay. However, some teachers interviewed may not be able
to tell the differences between the terms like "information and communication technology" and "information technology". It is up to the researcher to tell the difference and hence this may resulted in instrument decay.

- Non-response bias: This survey questionnaire adopted an anonymous approach in order to minimize potential ethical issues. However, the approach resulted in a situation that the researcher could not trace who had not returned the survey questionnaire. This resulted in a question that can hardly be accurately answered: Will non-respondents have very different views or opinions towards the use ICT for teaching and learning when compared to respondents? The situation that 59% of the respondents did not return the questionnaire was a bit disappointing even with all the effort outlined above. It was recognized without reservation that the above mentioned situation was a limitation of this study.

- Respondent’s attributes: For the use of ICT for teaching and learning, some attributes like age, gender, personal interest in computer and personal experience different technology may affect respondents’ responses to items in the survey instrument or questions asked in the interview in a subtle way. As the respondents have diverse background, their attributes are likely to be very different. Hence, it is essential to include the analysis of belief constructs against the attributes mentioned.

- Respondent’s perceptions: It is known that beliefs are tacit in nature and it is necessary to make use of some operational definitions in order to gather valid data. This study used operational definitions of beliefs from previous studies; hence, the measurement could be done precisely. However, there will certainly be some perception issue arise in interviews. For instance, teachers may think the term WebQuest (Dodge, 2001) has the same meaning as doing research on the Internet. This type of issue can only be addressed in face-to-face interviews or on other occasions with the presence of the researcher.
4. Quantitative Results and Interpretations

4.1 Introduction

This chapter is intended to report the findings from quantitative data, and how they are interpreted in the specific context of the study, and if possible, with the support of relevant research findings. The first part of this chapter aims to report descriptive data analysis of the demographics of the subjects in this study, and to present arguments that the subjects in this study are a good representation of the population (i.e. all chemistry teachers in Hong Kong). After that, the data related to the kinds of ICT-based tools the subjects are using will be presented (i.e. information related to the first research question of this study). The data associated with the three beliefs, perceived usefulness (PU), perceived ease of use (PEoU) and context beliefs (CONTX), and how they are related to the use of ICT teaching and learning tools will be presented (i.e. information related to the second, third and fourth research questions of this study).

- What are teachers' PU and PEoU about the use of ICT-based tools?
- What are teachers' CONTX about the use of ICT-based tools?
- What are the relationships between the use of ICT-based tools and teacher beliefs (as exemplified by PU, PEoU and CONTX)?

Towards the end of this chapter, the relationships between different variables concerning how teachers use ICT-based tools will be presented.

4.2 Response rate

The study was carried out in Hong Kong with data gathered from in-service chemistry teachers using a self-completed questionnaire (Appendix C). Questionnaires were
distributed to chemistry teachers in different professional development related activities and returned by mail or right at the training venues. Three hundred questionnaires were handed out to teachers, and one hundred and twenty-four questionnaires were returned by mail. Two questionnaires returned had a lot of questions not answered, and hence they were excluded from the analysis. Hence, the overall response rate was about 41%. The response rate of this questionnaire survey is indeed a bit low and the findings may be challenged by academics.

Babbie (2004) suggests a 50 percent response rate is adequate for analysis and reporting, a 60 percent response rate is good, and a 70 percent response rate is very good. Furthermore, he argues that a demonstrated lack of response bias is far more important than a high response rate (p.261). Holbrook, Krosnick and Pfent (2008) assessed the impact of response rate on the accuracy of survey results by examining 81 national surveys with response rates varying from 5 percent to 54 percent, and they found that surveys with much lower response rates were only minimally less accurate (cited in "Response Rate" in Wikipedia, 2008). With reference to the remarks made by the academics, the response rate of this study will be only minimally less accurate than one with a high response rate, provided that the study will be free from response bias.

The following paragraphs will report the demographics of respondents, and to outline the relevant results of the data analysis to demonstrate the response bias is not significant in this study.
4.3 Teachers' working environment (exogenous demographic data)

Based on the valid questionnaires, a number of descriptive statistical analyses were carried out based on the data gathered from the items in the questionnaire. The purpose of the analyses was to provide a clear picture of the subjects. The section below first reports the subjects' working environment, i.e. the information about the schools at which the subjects were working.

There are five main types of schools in Hong Kong, as classified by the school management organizations and by the funding models. The government schools are managed and funded by the HKSAR government. The aided secondary schools are managed by non-government organizations but funded by the government using the model prescribed in "code-of-aid". The caput and direct subsidized schools (DSS) are managed by non-government organizations, but funded by the government using an alternative funding model. Lastly, the private schools are not funded by the government.

According to the territory wide data on secondary education provided by the Education and Manpower Bureau for the year 2006-2007 (Appendix F), there are 36 government schools (6.79 percent), 375 aided schools (70.75 percent), 8 caput schools (1.51 percent) and 106 DSS/Private schools (20 percent) in Hong Kong. A comparison of the types of school that participated in this study and the territory wide data revealed that the schools included in this study are representative, though a perfect match is not achieved.
### Table 4.1 Types of school participated

#### Types of school \((n=120)\)

- Government \((n=10, 8\%)\)
- Aided \((n=98, 82\%)\)
- Caput \((n=1, 1\%)\)
- DSS/Private \((n=11, 9\%)\)

To avoid misleading the readers, it is imperative here to state the fact that there are three different types of schools not included in this study: special schools, private international schools and schools operated by the English Schools Foundation (ESF) Hong Kong. Special schools are excluded from this study as they will not operate chemistry courses, and the later two types of schools are also excluded for the reason that they operate quite different chemistry curricula such as those designed by the International Baccalaureate Organization and organizations such as OCR and Edexcel of the United Kingdom. Teachers will be making teaching and learning decisions that are quite different from those implementing local chemistry curricula.
Table 4.2 Distribution of the schools participated

<table>
<thead>
<tr>
<th>School district (n=119)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong Island (33, 28%)</td>
<td>40</td>
</tr>
<tr>
<td>Kowloon (43, 36%)</td>
<td>50</td>
</tr>
<tr>
<td>New Territories East (19, 16%)</td>
<td>30</td>
</tr>
<tr>
<td>New Territories West (24, 20%)</td>
<td>20</td>
</tr>
</tbody>
</table>

Once again, with reference to the statistics provided by the Education and Manpower Bureau for the year 2006-2007 (Appendix F), there are 113 schools in Hong Kong Island Region (21.32 percent), 183 schools in Kowloon Region (34.53 percent), 98 schools in New Territories East Region (18.49 percent) and 136 schools in New Territories West (25.66 percent). A comparison of the geographical locations of the schools participating in this study and the territory wide data revealed that the schools included in this study are representative.

When inspecting the data gathered from the question asking how the subjects perceive the abilities of their students, they reported a reasonably symmetrical and unimodal distribution of student ability, i.e. there is a close to normal distribution of student ability\(^1\). As there are a large number of secondary school students in Hong Kong, the distribution of their abilities

\(^1\) Before admitted to secondary schools, all primary school pupils will be assessed and subsequently be classified, in a descending order of assessment results, into three territory bands: first, second and third respectively (EDB, 2009c).
is expected to be normal. Hence, the subjects participating in this study are quite representative of all the chemistry teachers in Hong Kong.

Table 4.3 Ability of students in the schools participated

<table>
<thead>
<tr>
<th>Student ability (n=120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High (36, 30%)</td>
</tr>
<tr>
<td>• Average (58, 48%)</td>
</tr>
<tr>
<td>• Low (26, 22%)</td>
</tr>
</tbody>
</table>

To conclude this part of the data analysis, it can be said that the subjects in this study are working in a range of different schools which can be regarded as a good representation of all the secondary schools in Hong Kong. In other words, any conclusions developed from the data provided by the subjects are reasonably "generalizable" with respect to secondary schools in Hong Kong.
4.4 Teachers’ personal attributes (endogenous demographic data)

The previous section presents some exogenous demographic data of subjects participating in this study. This section reports the personal attributes of subjects, i.e. age, gender, qualifications in science and in education, teaching experience, position in chemistry department and information technology competency level.

From Table 4.4 below, it is known that two thirds of the subjects in this study are male. There will be a number of questions linked to the gender of subjects. For instance, will the male and the female subjects have different beliefs towards the use of ICT for teaching and learning? Will the male subjects use more ICT tools for teaching and learning tools than their female counterpart?

Table 4.4 Gender of the subjects

<table>
<thead>
<tr>
<th>Gender</th>
<th>(n=120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>(80, 67%)</td>
</tr>
<tr>
<td>Female</td>
<td>(40, 33%)</td>
</tr>
</tbody>
</table>

From the information listed, it is clear that the subjects are well educated: all of them have bachelor or above degrees in science, and all of them have a Diploma in Education, Dip.Ed (or postgraduate diploma in education, P.G.D.E.). In addition, there is 27 percent of the subjects having master or above degrees in education. Notwithstanding the above...
information suggested that the subjects are professionally trained in education (Table 4.5). Also, only one sixth of the subjects have a master degree in education. Will graduate study in education still have an impact on teaching and learning in classrooms? To further the discussion, it is needed to reflect on whether in-service teacher education will have an impact on teaching and learning practices in classrooms. Are in-service teacher education programmes effective enough to make teachers change their practices and their beliefs about teaching and learning strategies? These are questions to be addressed.

Table 4.5 Qualification of the subjects in science

<table>
<thead>
<tr>
<th>Highest qualification in science (n=120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• B.Sc. (88, 73%)</td>
</tr>
<tr>
<td>• MSc (29, 24%)</td>
</tr>
<tr>
<td>• PhD (3, 3%)</td>
</tr>
</tbody>
</table>

Table 4.6 Qualification of the subjects in education

<table>
<thead>
<tr>
<th>Highest qualification in education (n=120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dip.Ed./P.G.D.E. (100, 83%)</td>
</tr>
<tr>
<td>• MEd (20, 17%)</td>
</tr>
<tr>
<td>• PhD/EdD (0, 0%)</td>
</tr>
</tbody>
</table>
About 73 percent of the subjects are 31 to 50 years of age. Suppose the subjects start their education career right after graduation, they have at least 7 to 8 years of teaching experience, or they have been teaching for some 20 years. As indicated in Table 4.8, 28% and 44% of subjects have respectively 11-15 years and 16 or more years of teaching experience. In short, it is reasonable to argue that the majority of the subjects are experienced.

Table 4.7  Age distribution of the subjects

<table>
<thead>
<tr>
<th>Age</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-30</td>
<td>16</td>
<td>13%</td>
</tr>
<tr>
<td>31-40</td>
<td>45</td>
<td>38%</td>
</tr>
<tr>
<td>41-50</td>
<td>43</td>
<td>36%</td>
</tr>
<tr>
<td>51 or above</td>
<td>16</td>
<td>13%</td>
</tr>
</tbody>
</table>
About 72 percent of the subjects have more than 10 years of experience. Among the subgroups, about 62 percent of them have more than 15 years of experience. From the above data, it is possible to say the subjects are experienced chemistry teachers. This group of teachers should have a well-developed repertoire of teaching and learning strategies which are believed to be effective. Hence, it is postulated that the subjects will have a stable set of beliefs about teaching and learning. Have ICT-based teaching and learning strategies been included into the said repertoire?

Table 4.8 Teaching experience of the subjects

<table>
<thead>
<tr>
<th>Teaching experience in years (n=120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 (19, 16%)</td>
</tr>
<tr>
<td>6-10 (15, 13%)</td>
</tr>
<tr>
<td>11-15 (33, 28%)</td>
</tr>
<tr>
<td>16 or above (53, 44%)</td>
</tr>
</tbody>
</table>

Based on the researcher's experience in working with chemistry teachers, just like other subject areas, teachers with many years of experience are likely to become the panel head of the Chemistry Department. It is therefore expected the three variables, age, teaching experience and position the Chemistry Department are related. Hence, the correlation coefficients of the three variables were computed.
The respective correlation coefficients of age and teaching experience ($r = .808$, $p < .001$), age and position in the Chemistry Department ($r = .424$, $p < .001$), and teaching experience and position in the Chemistry Department ($r = .523$, $p < .001$) reveal that the three variables are significantly related.

**Table 4.10 Correlation of age, teaching experience and position in the Chemistry Department**

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Teaching Experience</th>
<th>Position in the Chem Dept</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>1</td>
<td>.808(**)</td>
<td>.424(**)</td>
</tr>
<tr>
<td><strong>Teaching Experience</strong></td>
<td>.000</td>
<td>1</td>
<td>.523(**)</td>
</tr>
<tr>
<td><strong>Position in the Chemistry Department</strong></td>
<td>.424(**)</td>
<td>.523(**)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Correlation is significant at the .01 level (2-tailed).**
From Table 4.11 below, more than 85 percent of the subjects in this study have Intermediate Level or Upper-Intermediate Level of ICT competency. It is quite reasonable to postulate that if the subjects decided to use ICT for teaching and learning, their ICT competency should not be a barrier. However, it should be explicitly stated that the ICT competency of the subjects may not be a good indicator that the subjects will adopt ICT based pedagogies in their classrooms. More information from other sources will be needed to put forward conclusion about whether teachers will use ICT based pedagogies.

Table 4.11 Information technology competency level of the subjects

<table>
<thead>
<tr>
<th>ICT competency level (n=119)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Basic Level (9, 7%)</td>
</tr>
<tr>
<td>• Intermediate Level (45, 38%)</td>
</tr>
<tr>
<td>• Upper-Intermediate Level (57, 48%)</td>
</tr>
<tr>
<td>• Advanced Level (8, 7%)</td>
</tr>
</tbody>
</table>

To summarize this section, it is possible to say that the subjects in the study are mature, male-dominated, well-educated and experienced teachers with a high level of ICT competency. As there are no territory-wide data on the attributes of chemistry teachers, based on the work experience of the researcher in the field, it is possible to argue that the subjects in this study are a good representation of all chemistry teachers in Hong Kong.
4.5 Are teachers using ICT-based tools?

Subjects were requested to indicate their frequencies of use of 14 different ICT-based teaching and learning tools (Section A of the survey questionnaire). With the information gathered, the variable ICT_usage (a frequency index used in this study to summarizing the extent of the use of ICT-based tools) is then computed from the subject’s responses. Firstly, the option checked in each item is converted to a score of 1, 2, 3, 4 or 5, according to the increasing frequency of the use of the ICT tools.

Table 4.12  Frequency of use of the ICT-based tools and frequency index

<table>
<thead>
<tr>
<th>Frequency of use of the ICT-based tools in the last school year</th>
<th>Frequency Index (ICT_usage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not used at all</td>
<td>1</td>
</tr>
<tr>
<td>1-2 times</td>
<td>2</td>
</tr>
<tr>
<td>3-5 times</td>
<td>3</td>
</tr>
<tr>
<td>6-10 times</td>
<td>4</td>
</tr>
<tr>
<td>More than 10 times</td>
<td>5</td>
</tr>
</tbody>
</table>

After the conversion, all the scores assigned are added up to give the value of ICT_usage. The ICT_usage will have a minimum value of 14, this indicates the subject concerned is not at all an ICT user. On the other extreme, the ICT_usage will have a maximum value of 70, this indicates the subject concerned is a very regular ICT user.
As an example, the figure below shows the options checked by a subject.

<table>
<thead>
<tr>
<th>ICT-based tools</th>
<th>Nil</th>
<th>1-2</th>
<th>3-5</th>
<th>6-10</th>
<th>More than 10</th>
<th>ICT_usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Word Processing</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
<td>5</td>
</tr>
<tr>
<td>2 Spreadsheet</td>
<td>☐</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>2</td>
</tr>
<tr>
<td>3 Presentation</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
<td>5</td>
</tr>
<tr>
<td>4 Animation</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>1</td>
</tr>
<tr>
<td>5 Drill and Practice</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>1</td>
</tr>
<tr>
<td>6 ...</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>14 ...</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

**Figure 4.1 Computing ICT_usage scores**

The subject scored 5 in Word Processing, 2 in Spreadsheet, 5 in Presentation, and scored 1 in the remaining eleven ICT-based tools starting from "Animation". After summing up all the scores, he or she had an ICT_usage score of 23. In this case, the subject is using the office automation tools extensively, but none of the other tools. Hence, he or she can be using ICT for preparation of lessons and for presentation. The pedagogical strength of other tools is yet to be fully utilized.

From Table 4.13 below, the mean of the ICT_usage value is 36. It is possible to say that all the subjects are using some of the ICT-based tools listed in the questionnaire. If a subject is using all the office automatic tools more than 10 times per year but none of the other tools, he or she has an ICT_usage score of 26 only. Hence, this suggests that all the subjects are using some tools other than the office automation tools. What exact kinds of tools the subjects were using will be outlined in Section 4.6.
The minimum ICT_usage score was 18. This suggests that low level ICT users are using at least one or two ICT-based tools. This is a very good piece of evidence for the fact that ICT-based tools have become essential to teachers. On the other end of the spectrum, there are no subjects using ICT-based tools very extensively as shown by the maximum ICT_usage score being 52, which is much lower than the maximum possible score. Together with the fact that none of the subjects are included in the group of ICT_usage score range of 56 to 70, it is thus argued that the subjects are using ICT for teaching and learning, but ICT is not the most dominant pedagogy, the subjects are using other strategies as well.

Table 4.13 Descriptive statistics of ICT_usage

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT_usage</td>
<td>109</td>
<td>18.00</td>
<td>52.00</td>
<td>35.98</td>
<td>7.18</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>109</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.2 ICT_usage scores of subjects
This next part of the discussion attempts to report results of the inferential statistical analyses on the usage of ICT-based tools. The use of ICT-based tools (a continuous data) was analyzed against the school characteristics: type of school, school district and student ability (three sets of categorical data). To compare the means of a continuous data with reference to several categorical data, one-way ANOVA is the most appropriate technique. It is found that there were no statistically significant differences in the ICT_usage for different types of school (F= .929, p= .429) and for school in different districts (F=1.290, p= .282). However, a statistically significant difference at the .05 level is found in the ICT_usage for the variable student ability (F=4.146, p= .018).

Table 4.14  ANOVA of ICT_usage against student ability

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>404.409</td>
<td>2</td>
<td>202.205</td>
<td>4.146</td>
<td>.018</td>
</tr>
<tr>
<td>Within Groups</td>
<td>5169.554</td>
<td>106</td>
<td>48.769</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5573.963</td>
<td>108</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Levene statistic = 1.572 & p= .213, the groups can be assumed to have equal variance.

The results of post hoc tests on ICT_usage (Bonferroni) suggested that teachers of students with "high ability" and "low ability" have a statistically significant difference in the use of ICT at the .05 level. However, there were no such differences among "high ability" and "average ability" groups, and "average ability" and "low ability" groups at the .05 level. In addition, it is also observed from Table 4.15 below that teachers with students having "low ability" are less likely to use ICT-based tools. It is thus speculated that teachers would make decisions on using ICT-based tools, at least partially, based on the abilities of their students.
Table 4.15  Descriptive statistics of ICT_usage and student ability

<table>
<thead>
<tr>
<th>Student Ability</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% CI for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>32</td>
<td>37.8750</td>
<td>7.85247</td>
<td>1.38813</td>
<td>35.0439</td>
<td>40.7061</td>
<td>22.00</td>
</tr>
<tr>
<td>Average</td>
<td>54</td>
<td>36.3519</td>
<td>6.94767</td>
<td>.94546</td>
<td>34.4555</td>
<td>38.2482</td>
<td>18.00</td>
</tr>
<tr>
<td>Low</td>
<td>23</td>
<td>32.4783</td>
<td>5.63971</td>
<td>1.17596</td>
<td>30.0395</td>
<td>34.9171</td>
<td>23.00</td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td>35.9817</td>
<td>7.18406</td>
<td>.68811</td>
<td>34.6177</td>
<td>37.3456</td>
<td>18.00</td>
</tr>
</tbody>
</table>

The use of ICT-based tools was then analyzed against the teacher's personal attributes: age, gender, qualification in science, qualification in education, teaching experience, position in the Chemistry Department and ICT competency level. It was found that there were no statistically significant differences in the ICT_usage for age (F=.575, p=.633), for gender (t=1.010, p=.315), for qualification in science (F=.125, p=.882), for qualification in education (F=.263, p=.609), for teaching experience (F=1.051, p=.373) and for position in the Chemistry Department (t=-.746, p=.457). However, a statistically significant difference at the .05 level is found in the ICT_usage for the variable ICT competency level (F=3.577, p=.016).

Table 4.16  ANOVA of ICT_usage against ICT competency level

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>521.296</td>
<td>3</td>
<td>173.765</td>
<td>3.577</td>
<td>.016</td>
</tr>
<tr>
<td>Within Groups</td>
<td>5051.620</td>
<td>104</td>
<td>48.573</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5572.917</td>
<td>107</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Levene statistic = 1.897 & p=.135, the groups can be assumed to have equal variance.
The results of post hoc tests on ICT_usage (Bonferroni) suggested that "AIT" teachers and "BIT" teachers have statistically significant mean difference in the use of ICT at the .05 level. However, there were no such differences among other groups at the .05 level. It is also observed from Table 4.17 below that the subjects with the highest competency level have the highest minimum and maximum, as well as the highest mean ICT_usage. In addition, the higher the ICT competency level, the higher is the level of use of ICT-based tools for teaching and learning. It is thus speculated that teachers would make decisions to use ICT-based tools, at least partially, based on the own competency or self-efficacy in using ICT (Bandura, 1996). The relationship will have to be further explored in the non-dominant part of this study, and discussion on the relevant findings will be presented in Chapter 5.

Table 4.17 Descriptive statistics of ICT_usage and ICT competency level

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% CI for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIT</td>
<td>7</td>
<td>30.8571</td>
<td>3.80476</td>
<td>1.43806</td>
<td>27.3383</td>
<td>34.3760</td>
<td>26.00</td>
</tr>
<tr>
<td>BIT</td>
<td>40</td>
<td>34.6750</td>
<td>6.92594</td>
<td>1.09509</td>
<td>32.4600</td>
<td>36.8900</td>
<td>18.00</td>
</tr>
<tr>
<td>UIT</td>
<td>53</td>
<td>36.8113</td>
<td>7.33552</td>
<td>1.00761</td>
<td>34.7894</td>
<td>38.8332</td>
<td>23.00</td>
</tr>
<tr>
<td>AIT</td>
<td>8</td>
<td>41.3750</td>
<td>6.50137</td>
<td>2.29858</td>
<td>35.8397</td>
<td>46.8103</td>
<td>35.00</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
<td>35.9722</td>
<td>7.21688</td>
<td>.69444</td>
<td>34.5956</td>
<td>37.3489</td>
<td>18.00</td>
</tr>
</tbody>
</table>
4.6 What kinds of ICT-based tools teachers use?

As discussed in section 4.5, the variable ICT_usage reveals an overall picture of how the subjects are using ICT-based tools. This section attempts to further investigate the types of ICT-based tools being used for teaching and learning. In other words, the following paragraphs will report how frequently different ICT-based tools are being used.

![Figure 4.3 Frequency Index of the Use of ICT-based Tools](image)

**Figure 4.3 Frequency Index of the Use of ICT-based Tools**

With reference to the "teaching styles" proposed by Gobbo and Girardi (2001) and other studies (Bebell, Russell & O'Dwyer, 2004; Wong & Li, 2006), together with the nature of the fourteen ICT-based tools, it is suggested to classify the tools into five different categories, namely, office automation tools, didactic-oriented tools, process-oriented tools, constructivist-oriented tools, and authoring tools (Appendix E).
a. Office Automation Tools

With reference to Figure 4.3 above, it is clear that office automation tools, i.e. word processing, spreadsheet and presentation, are very commonly used by chemistry teachers, despite the fact that the use of spreadsheet is comparatively less frequent. With reference to the fact that teachers have high frequencies of use of these tools, it can be proposed that professional development courses on the use of these tools and the provisions of computers equipped with such tools to schools in the first phase of the IT in Education Project (EMB, 1998) have been very successful. Teachers are quite comfortable with the use of these tools. The high frequency of use of office automation tools is an impetus that drives, but not an indicator that predicts, the use of ICT in classrooms for teaching and learning purposes. In other words, the finding that teachers reported very frequent use of office automation tools cannot be regarded as a definitive indicator of the use of ICT in teaching and learning at the classroom level. Teachers can be using ICT-based tools for "preparation" and "professional email" but not necessarily for "delivering instruction" or "student use" (Bebell, Russell & O'Dwyer, 2004).

b. Didactic-oriented tools

When compared with office automation tools, it is not difficult to observe that the didactic-oriented tools, i.e. animation, drill and practice, tutorial and multimedia package, are less commonly used. The use of such tools in teaching and learning has been encouraged by a number of strategies. First of all, many didactic-oriented tools are provided free-of-charge to chemistry teachers by the Education and Manpower Bureau (EMB, 2003; 2004) and the Chinese University of Hong Kong (Cheung, 2006). Secondly, the tools are mostly designed to be "web-ready", hence teachers and students have no difficulty to access and use such tools via the school's intranet systems or through the Internet. Furthermore, the hardware and software required to use such tools for teaching and learning
are readily available to almost all the secondary schools in Hong Kong (EMB, 2004). Together with the fact that operating such tools is not difficult, it is possible to conclude that there are no major hindrances to the deployment of such tools for the teaching and learning of chemistry. It appears that there are some implicit factors operating, resulting in a relatively low frequency of use, and some competing pedagogical practices which are more appealing to teachers, are operating. The exact details of these practices have to be further investigated.

c. Process-oriented tools

It is clear from Figure 4.3 that the third category of tools, i.e. simulation, data-logging systems and WebQuest, are much less frequently used when compared to office automation tools and didactic-oriented tools. Among these tools, simulation is the most widely used. It is known that, as an example, simulation shareware on chemical equilibrium, "Equil (v1.0)“, is easily available on the web, can be used without paying the minimal cost (US$10), but helps students grasp abstract concepts in the topic “chemical equilibrium” in the advanced level chemistry curriculum. Furthermore, the use of “Equil (v1.0)” has been promoted through the chemistry teachers’ organization. Thus, it is not unreasonable to observe a quite wide use of simulation.

Data-logging systems and Webquest have rather low frequencies of use. Data-logging systems are in fact widely promoted through professional development courses for teachers, and are made accessible to teachers through various funding methods, for instance, by application to the Quality Education Fund using various ICT in Education Project titles. As a result, many secondary schools have already acquired quite a number of data-logging systems. Nevertheless, the operation of a data-logging system is more complicated compared to other tools. Furthermore, the benefits of using data-logging systems are not
well documented or well communicated to teachers. Teachers, being pragmatic professionals (Waller, 2007), may not take the trouble of using the data-logging systems without being shown very explicitly the benefits of their uses. Teachers can always resort to the use of traditional ways of carrying out practical work.

The use of Webquest (Dodge, 2001) for teaching and learning has been recently promoted through the collaboration between faculties of Education and the Education and Manpower Bureau. However, the professional development courses on Webquest are designed to fit all teachers, irrespective of the teaching subject or their teaching levels, primary or secondary. Also, the documented benefits of deployment of the tool in teaching and learning are not yet available. Hence, it is not difficult to explain the relatively low level of use.

d. Constructivist-oriented tools

It is perhaps a very disappointing fact for advocates of the constructivist pedagogical approach, such as Hewson and Hewson (1988), to see the very low frequencies of the use of constructivist-oriented tools, like ChemSense, e-Group and Knowledge Forum. Hewson and Hewson (1988) advocate "appropriate conceptions to science teaching" and the "conceptual change model"; and they argue that the constructivist pedagogical approach should be used in science subjects. However, just as Koballa, Graber, Coleman and Kemp (2000) reported in their small scale phenomenological study in Germany, many chemistry teachers conceptualized "chemistry learning as gaining knowledge" and "chemistry teaching as transferring knowledge". Through frequent contact between the researcher and a number of chemistry teachers in Hong Kong, it was observed that many of them have the said concepts, which can be a reason to explain the low level of use of these constructivist-oriented tools.
Within the category of constructivist-oriented tools, and among all the tools listed in the survey instrument, the frequency of use of ChemSense is the lowest. Only a small number of chemistry teachers recognize the existence of this chemistry subject-specific and constructivist-oriented tool which is available free-of-charge on the Internet (CS, 2005). Furthermore, since there are only a very limited number of, or perhaps literally no professional development courses on the tool, it is not a surprise to have the said finding.

e. Authoring tools

The authoring tool (Macromedia or Adobe Authorware) was the second least frequently used tool. Being a named software tool in the teachers’ ICT competency framework (EDB, 1998), together with more than 50% of subjects having ICT competency at Upper-intermediate Level or above, the frequency of use is remarkably low. To attain Upper-Intermediate ICT competency level, it is however not necessary to use Authorware to develop teaching materials, teachers can use alternatives such as Frontpage, or they can develop a paper and pencil version of a scheme of work with multimedia learning. It is not surprising to hear teachers argue against the inclusion of an authoring tool like Authorware in the teachers’ ICT competency framework (Au, Kong, Leung, Ng & Pun, 1999, or Appendix A). Gifford (2004) argued that using technology for instruction will further complicate the already complex teaching profession. It is argue here that Authorware is inherently complicated to operate, hence the use of the tool will further complicate the teaching profession. More importantly, we should review the role of teachers: should they be producers of multimedia learning materials or should they focus on something already in their repertoires?
4.7 Teachers' perceived usefulness (PU) of the ICT-based tools

To answer the second research question, it is necessary to solicit data about the following teachers' beliefs about the ICT-based tools:

a. teachers' perceived usefulness (PU); and

b. teachers' perceived ease of use (PEoU).

As discussed in Chapter 2, the Technology Acceptance Model (TAM) advocated by Davis (1989) has been widely used in a range of different research areas (Rose & Struab, 1999; Yuen & Ma, 2002; Miller & Khera, 2010), and its instrument can validly and reliably be used for gathering information about technology beliefs. In this study, the items in the TAM's instrument (Davis, 1989) were modified to five category Likert scales. The scales were then used as one of the key elements in the survey questionnaire (Appendix C). By combining the scores of the respective six survey items on PU and PEoU, the data about personal PU and PEoU of each subject could be obtained. The findings related to PU will be presented first while those for PEoU will be presented in the next section.

In this part, the descriptive statistics, i.e. minimum, maximum, mean, standard deviation and distribution, on PU will be presented first, followed by the results of some inferential statistical tests.

From Table 4.18, the mean PU value was 2.31, which indicates that the subjects perceived the ICT-based tools as being "somewhat likely" to be useful. It is possible to say that the subjects had a positive belief about the usefulness of the ICT-based tools. The range (3.83) and the standard deviation (.74) for the data set of PU suggested that the subjects had different beliefs about the usefulness of the ICT-based tools. In a nutshell, the subjects (and quite likely all the chemistry teachers) have positive yet a little diverse beliefs on the perceived usefulness of the ICT-based tools.
Table 4.18 Descriptive statistics of PU and PEoU

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Usefulness</td>
<td>121</td>
<td>1.00</td>
<td>4.83</td>
<td>2.3135</td>
<td>.74073</td>
</tr>
<tr>
<td>Perceived Ease of Use</td>
<td>121</td>
<td>1.00</td>
<td>4.00</td>
<td>1.8598</td>
<td>.56609</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>121</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Figure 4.4 below, it was possible to observe that the data set has a marked lop-sided distribution, alternatively, the PU data set is skewed to the right (skewness statistic=.857, std. error = .220). Only 8 out of 121 (or about 6.6%) and only 4 out of 121 (or about 3.3%) of the subjects considers the ICT-based tools respectively as "somewhat unlikely" and "very unlikely" to be useful in their jobs. The lion's share of subjects, over 90%, considers the ICT-based tools "very likely" and "somewhat likely" to be useful in their jobs. In summary, it was found that 9 out of 10 subjects believed that the ICT-based tools useful.

![Figure 4.4 Distribution of PU data](image)

As discussed in Chapter 3 and Sections 4.3 & 4.4, a number of factors like school type, gender, ICT competency level etc. were speculated to have influence on whether or not teachers would use the ICT-based tools. With reference to the nature of the said factors, they were classified into two types:
a. working environment: school type, school district and student ability; and

b. personal attributes: gender, age, qualification in science, qualification in education, teaching experience, position in the Chemistry Department and ICT competency level.

In order to find out whether the subjects' working environment would influence their PU, the inferential statistical test – one way analysis of variance (ANOVA) was carried out on the three factors. The results indicated there were no statistically significant differences in PU among subjects working in different environments. Details of the ANOVA results are shown in Table 4.19 below.

Table 4.19  ANOVA of PU against the variables related to working environment

<table>
<thead>
<tr>
<th>PU</th>
<th>School Type</th>
<th>School district</th>
<th>Student Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1.283</td>
<td>1.138</td>
<td>0.354</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.284</td>
<td>0.337</td>
<td>0.703</td>
</tr>
</tbody>
</table>

Turning to the personal attributes of subjects, the inferential test – one way ANOVA or t-test was carried out on each of the attributes. There were no statistically significant differences for the five personal attributes, namely, qualification in science, qualification in education, age, teaching experience and position in the Chemistry Department. Details of the inferential test results are shown in Table 4.20 below.

Table 4.20  ANOVA/t-test of PU against some variables related to personal attributes

<table>
<thead>
<tr>
<th>PU</th>
<th>Qualification in Science</th>
<th>Qualification in Education</th>
<th>Age</th>
<th>Teaching Experience</th>
<th>Position in Chemistry Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1.327</td>
<td>.015</td>
<td>1.404</td>
<td>.164</td>
<td>-.450 (t-test)</td>
</tr>
<tr>
<td>Sig.</td>
<td>.269</td>
<td>.902</td>
<td>.245</td>
<td>.920</td>
<td>.654</td>
</tr>
</tbody>
</table>
From Table 4.21 below, the mean PU value for male subjects (2.14) is much lower than that for female subjects (2.70). It is possible to say male subjects perceived the ICT-based tools as more useful for teaching and learning than their female counterparts. In addition, according to the results of a t-test on PU against gender shown in Table 4.22 below, there is a statistically significant difference for mean PU values between male and female subjects at the .05 level ($t=-4.127$, $p=.000$).

Table 4.21 Descriptive statistics of PU and gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>80</td>
<td>2.1388</td>
<td>.62134</td>
<td>.06947</td>
</tr>
<tr>
<td>Female</td>
<td>39</td>
<td>2.7009</td>
<td>.83349</td>
<td>.13347</td>
</tr>
</tbody>
</table>

Table 4.22 t-test of PU against gender

<table>
<thead>
<tr>
<th>Perceived Usefulness</th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>T</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>2.835</td>
<td>.095</td>
<td>-4.127</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-3.736</td>
<td>.000</td>
<td>-3.736</td>
</tr>
</tbody>
</table>

It is thus speculated that male and female chemistry teachers have different beliefs about usefulness of the ICT-based tools, hence they would make different teaching and learning decisions related to ICT. This relationship will be explored in the non-dominant part of this study.

On the ICT competency level, from Table 4.23 below, the mean PU values decrease as the ICT competency level of the subjects increase, i.e. a decrease from 2.57 to 1.77. In addition, it is observed that all the subjects attained the AIT competency level had a marked
positive PU belief. From Table 4.24, the results of ANOVA on PU against ICT competency level show a statistically significant difference among mean PU values at the .05 level \( (F=2.832, p=.041) \). It is thus possible to argue that a chemistry teacher with a higher ICT competency will perceive the ICT-based tools as more useful for teaching and learning than one with a lower ICT competency.

For this study, it is known that there were respectively only 9 and 8 subjects with BIT and AIT qualifications (Table 4.23). At first sight, the small number of subjects involved appeared to be a limitation. However, after a reflection this limitation was not an issue. In all local secondary schools (around 500), among 60 teachers in each school only one of them would be awarded the AIT qualification. Thus, in the actual population (i.e. all Hong Kong chemistry teachers), there are not too many chemistry teachers with the AIT qualification. The situation is also similar in the case of BIT. Hence, this study is not deficient in the subjects with very low or very high ICT competency.

Table 4.23  Descriptive statistics of PU and ICT Competency Level

<table>
<thead>
<tr>
<th>Perceived Usefulness</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIT</td>
<td>9</td>
<td>2.5741</td>
<td>1.15503</td>
<td>.38501</td>
<td>1.6862</td>
<td>1.2</td>
<td>4.8</td>
</tr>
<tr>
<td>IIT</td>
<td>45</td>
<td>2.4800</td>
<td>.54885</td>
<td>.08182</td>
<td>2.3151</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>UIT</td>
<td>56</td>
<td>2.2381</td>
<td>.77516</td>
<td>.10358</td>
<td>2.0305</td>
<td>1.0</td>
<td>4.7</td>
</tr>
<tr>
<td>AIT</td>
<td>8</td>
<td>1.7708</td>
<td>.72340</td>
<td>.25576</td>
<td>1.1661</td>
<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td>2.3243</td>
<td>.74626</td>
<td>.06870</td>
<td>2.1882</td>
<td>1.0</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Table 4.24  ANOVA of PU against ICT Competency Level

<table>
<thead>
<tr>
<th>Perceived Usefulness</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>4.519</td>
<td>3</td>
<td>1.506</td>
<td>2.832</td>
<td>.041</td>
</tr>
<tr>
<td>Within Groups</td>
<td>60.638</td>
<td>114</td>
<td>.532</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>65.157</td>
<td>117</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Levene statistic = 2.543 & \( p=.060 \), the groups can be assumed to have equal variance.
The results of Bonferroni post hoc tests on PU suggest that teachers with different ICT competency levels have no statistically significant mean differences at the .05 level among the four groups. It is thus reasonable to speculate that chemistry teachers with a high ICT competency would perceive the ICT-based tools as more useful for teaching and learning than ones with a lower ICT competency. These findings can have an implication for teachers’ ICT training. If an education leader wishes to encourage teachers to use more ICT for teaching and learning, he or she can put in more resources that target increasing teachers’ ICT competency. In other words, teachers are encouraged to attain UIT or AIT level through different professional development opportunities. In addition, as argued by Gifford (2004, p.6), “effective professional development opportunities can influence essential changes in beliefs” and “both supporters and critics of technology concur effective professional development is critical to foster technology adoption”. Nevertheless, the said practice has to be exercised with care as there can be other factors (e.g. gender) operating at the same time. It is needed to deliberate on what are and how to provide effective professional development opportunities.

To summarize the discussion in this section, it is known that the great majority of subjects have a positive yet a bit diverse belief about usefulness of the ICT-based tools for teaching and learning. It is also known that there are no statistically significant differences in PU for subjects working in different type of schools, in different school districts and schools with different student ability. Furthermore, subjects with different personal attributes like age, teaching experience, position in the Chemistry Department, qualifications in science and in education have no statistically significant differences in PU. It is found that the male subjects have a more positive belief about usefulness than the female counterparts, and finally it is also known that the subjects with a higher ICT competency have a more positive belief about usefulness than those with a lower ICT competency.
4.8 Teachers' perceived ease of use (PEoU) of ICT-based tools

As mentioned in Section 4.7, data related to PEoU had been collected and analyzed. In this connection, this section will present findings from the data set of PEoU. The descriptive statistics of and the results of inferential statistical tests on PEoU will be presented here.

From Table 4.18 above, the mean PEoU value was 1.86. The said data clearly indicated that the subjects perceived the ICT-based tools as being easy to use. More precisely, the subjects believed that the ICT-based tools listed in the questionnaire were "somewhat likely" and "very likely" to be easy to use. The range (3.00) and the standard deviation (.57) for PEoU suggest that the subjects had quite concerted beliefs about the ease of use of the ICT-based tools. In short, the subjects (and quite likely all the chemistry teachers) have a positive belief about the perceived ease of use of the ICT-based tools. They have little difference in belief about ease of use when compared to that of usefulness.

From Figure 4.5 below, it was very obvious that the data set has a marked asymmetrical distribution. Alternatively, the PEoU data set is skewed to the right (skewness statistic=.421, std. error = .220). Only 2 out of 121 (or about 1.7%) of the subjects considered the ICT-based tools as "somewhat unlikely" easy to use. None of the subjects reported the ICT-based tools as "very unlikely" to be easy to use. Among the 121 subjects, 85 (or 70%) of them reported the ICT-based tools as "very likely" to be easy to use. Hence, it can be confidently argued that nearly all the subjects (and the chemistry teachers) believe that the ICT-based tools are easy to use. It is thus speculated that if teachers are not using the ICT-based tools, the reasons will be something other than ease of use. What exactly are the factors that might have hindered teachers from using ICT will need to be explored.
As mentioned in Section 4.7, ANOVA was carried out to analyze the relationship between PEOU and the subjects' working environment. More specifically speaking, ANOVA was carried out on each of the three factors – school type, school district and student ability. The results indicate there were no statistically significant differences in PEOU among subjects working in different environment. Details of the ANOVA results are shown in Table 4.25 below.

<table>
<thead>
<tr>
<th>PU</th>
<th>School Type</th>
<th>School district</th>
<th>Student Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>.723</td>
<td>.769</td>
<td>.514</td>
</tr>
<tr>
<td>Sig.</td>
<td>.540</td>
<td>.514</td>
<td>.600</td>
</tr>
</tbody>
</table>

The inferential test, one way ANOVA or t-test, was carried out to scrutinize PEOU and the personal attributes. The results indicate there were no statistically significant differences for the six personal attributes, namely, qualification in science, qualification in education, age, teaching experience, position in the Chemistry Department and ICT competency level. Details of the inferential test results are shown in Table 4.26 below.
As shown in Table 4.27 below, the mean PEoU value for male subjects (1.77) is lower than that for female subjects (2.09). It is possible to say male subjects perceived the ICT-based tools as more easy to use than their female counterparts. In addition, according to $t$-test analysis of PEoU against gender shown in Table 4.28 below, there is a statistically significant difference for mean PEoU values between male and female subjects at the .05 level ($t = -3.055, p = .003$).

It is thus speculated that male and female chemistry teachers have different beliefs about ease of use of the ICT-based tools, hence they are likely to make different teaching and learning decisions related to ICT. This relationship will be explored in the non-dominant part of this study.
From Table 4.29 below, it is observed that mean PEOU values gradually decrease as the ICT competency level of the subjects increase, i.e. a decrease from 2.06 to 1.46 from BIT to AIT. Even though it appeared that the subjects who attained the AIT competency level had a marked positive PEOU belief, however, as shown in Table 4.30, the results of ANOVA on PEOU against ICT competency level indicate no statistically significant difference among mean PEOU values at the .05 level (F=1.942, p=.127). It is thus possible to argue that the ICT competency level may not be a good indication of the subjects’ perception about whether ICT tools are easy to use. It will be interesting to know which variable, ICT competency level or PEOU, is a better indicator of a teacher’s actual capability to use ICT.

Table 4.29  Descriptive statistics of PEOU and ICT Competency Level

<table>
<thead>
<tr>
<th>Perceived Ease of Use</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
</tr>
<tr>
<td>BIT</td>
<td>9</td>
<td>2.0556</td>
<td>.61237</td>
<td>.20412</td>
<td>1.5848</td>
<td>2.5263</td>
<td>1.2</td>
</tr>
<tr>
<td>IIT</td>
<td>45</td>
<td>1.9267</td>
<td>.45873</td>
<td>.06838</td>
<td>1.7888</td>
<td>2.0645</td>
<td>1.0</td>
</tr>
<tr>
<td>UIT</td>
<td>56</td>
<td>1.8571</td>
<td>.61334</td>
<td>.08196</td>
<td>1.6929</td>
<td>2.0214</td>
<td>1.0</td>
</tr>
<tr>
<td>AIT</td>
<td>8</td>
<td>1.4583</td>
<td>.61560</td>
<td>.21765</td>
<td>.9437</td>
<td>1.9730</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td>1.8718</td>
<td>.56554</td>
<td>.05206</td>
<td>1.7686</td>
<td>1.9749</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 4.30  ANOVA of PEOU against ICT Competency Level

<table>
<thead>
<tr>
<th>Perceived Ease of Use</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1.819</td>
<td>3</td>
<td>.606</td>
<td>1.942</td>
<td>.127</td>
</tr>
<tr>
<td>Within Groups</td>
<td>35.602</td>
<td>114</td>
<td>.312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>37.421</td>
<td>117</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Levene statistic = .851 & p=.469, the groups can be assumed to have equal variance.

Based on the mean values indicated in Table 4.29 above, assuming that the subjects are reasonably good representatives of the population, the higher the chemistry teachers ICT
competency is, the more likely they would perceive the ICT-based tools as being easy to use. However, with reference to the ANOVA results, i.e. Table 4.30 above, the said relationship is not statistically significant.

To summarize the discussion in this section, it is found that the great majority of subjects have a positive and a reasonably concerted belief about ease of use of the ICT-based tools for teaching and learning. Nevertheless, subjects working in different types of school, in different school districts and schools with different student ability have no statistically significant differences in PEoU. Furthermore, subjects with different personal attributes like age, teaching experience, position in the Chemistry Department, qualification in science and education have no statistically significant differences in PEoU. It is however found that the male subjects have a more positive PEoU than the female counterparts, and the difference is statistically significant. Finally it is found that the subjects with a higher ICT competency have a more positive PEoU than the ones with a lower ICT competency, but there are no statistically significant differences.

4.9 Teachers' context belief (CONTX) of the use of ICT-based tools

To address the research question 3, i.e. what are teachers’ context beliefs about the use of ICT-based tools, it is needed to get data from the subjects using the instrument "Beliefs About Teaching with Technology" or BATT (Lumpe & Chambers, 2001). As mentioned in Chapter 2, the instrument BATT has reasonably good validity and reliability and hence it has been included as one of the key components of this study. Please see Chapter 3 for details about the validity and reliability of the instrument BATT. In addition, although the instrument BATT has been developed by non-local academics, it can be used directly in Hong Kong for the following reasons:
The items used in the two subscales are context free, i.e. people of all ethnic groups can understand the content, and people living in different parts of the world can also comprehend the instrument, and the language used is simple, i.e. as Hong Kong chemistry teachers are well educated, have good mastery of the English language (the majority of teachers in Hong Kong learnt with English in their undergraduate or graduate courses) and a high level of ICT competency, they should have no problem in understanding the content, and the meanings of the ICT jargons used in the instrument.

In the instrument BATT, there are fourteen categories of item in each of the two subscales. Details of the two subscales are as follows.

a. Context beliefs from the ENABLE subscale

Subjects had to indicate their beliefs whether external factors or people would enable them to attain the goal on a Likert's scale: strongly agree (1) to strongly disagree (5) for each of the fourteen items in this subscale. The total of all the scores of the fourteen items is the subject's ENABLE subscale score. The possible range of raw score for this subscale is therefore 14-70.

b. Context beliefs from the LIKELIHOOD subscale

Subjects had to indicate their perceptions of possible occurrence of the external factors or people that would help them to attain the goal on a Likert's scale: very likely (1) to very unlikely (5) to occur to the fourteen items in this subscale. The total of all the scores of the fourteen items is the subject's LIKELIHOOD subscale score. The possible range of raw score for this subscale is also 14-70.

By combining the scores from the two subscales, the required CONTX raw score for each subject could be obtained. The possible range of this scale is therefore 28-140.
In this section, the descriptive statistics, i.e. minimum, maximum, mean, standard deviation and distribution, on ENABLE and LIKELIHOOD will be presented first, followed by the results of some inferential statistical tests.

From Table 4.31 below, the mean score of the ENABLE subscale was 24.73 (SD=5.39) out of the maximum value of 70. In other words, the subjects have quite positive beliefs that the external factors or people can enable them to reach the goal - to use ICT-based tools. In addition, with the distribution information of ENABLE from Figure 4.7, it is clear that there exists a positive skew (skewness statistics = .10). To put it simply, almost all the subjects have strong beliefs that external factors or people would enable them to attain the goal of using ICT for teaching and learning.

Also from Table 4.31 below, the mean score of the LIKELIHOOD subscale was only 35.96 (SD=7.77), out of the maximum value of 70. As the mean LIKELIHOOD score is just marginally higher than the mid score 42, it is possible to say that the subjects have only a slightly positive belief that external factors or people that can facilitate them to reach the goal will be likely to occur. In other words, the subjects have only limited trust that external factors or people will likely be available to help them. In addition, with the distribution information from Figure 4.7, it is clear that a quite normal distribution of a diverse LIKELIHOOD scores is found. The slightly positive and a bit diverse LIKELIHOOD belief may be related to the authentic experience gained daily in teachers' working environment.

Table 4.31  Descriptive statistics of ENABLE and LIKELIHOOD

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENABLE</td>
<td>119</td>
<td>15.00</td>
<td>42.00</td>
<td>24.7311</td>
<td>5.39255</td>
</tr>
<tr>
<td>LIKELIHOOD</td>
<td>114</td>
<td>20.00</td>
<td>56.00</td>
<td>35.9561</td>
<td>7.76809</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>113</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

106
Comparing the raw scores in the two subscales, ENABLE and LIKELIHOOD, it is obvious that the subjects have less positive beliefs that external factors or people will likely be available to help them achieve the goal of using ICT-based tools. The range statistics for ENABLE subscale (15 to 42) and LIKELIHOOD subscale (20 to 56) also confirm the aforementioned finding. How can we explain the difference between the subjects’ beliefs revealed by the in ENABLE and LIKELIHOOD scores? Is it related to the inadequate support provided by the school management? Is it related to the limited support of non-government teacher’s organizations such as The Hong Kong Association for Computer Education or Hong Kong Association for Science and Mathematics Education? Is it related to the curtailed support from the Information Technology Education Section of the Education Bureau of the HKSAR government in recent years? Is it related to the shrinking ICT support within schools?

To better communicate the data related to the two said subscales, the raw scores from ENABLE and LIKELIHOOD subscales are recoded using the following scheme.

<table>
<thead>
<tr>
<th>ENABLE Raw Score</th>
<th>LIKELIHOOD Raw Score</th>
<th>Recoded Score</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-20</td>
<td>14-20</td>
<td>1</td>
<td>Strong belief</td>
</tr>
<tr>
<td>21-27</td>
<td>21-27</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>28-34</td>
<td>28-34</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>35-41</td>
<td>35-41</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>42-48</td>
<td>42-48</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>49-55</td>
<td>49-55</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>56-62</td>
<td>56-62</td>
<td>7</td>
<td>Weak belief</td>
</tr>
<tr>
<td>63-70</td>
<td>63-70</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.6 Recoding of ENABLE and LIKELIHOOD scores
The distribution of recoded scores for ENABLE and LIKELIHOOD are shown in Figure 4.7.

In the same way mentioned in Section 4.7, ANOVA was carried out to analyze the relationship between ENABLE & LIKELIHOOD and the subjects’ working environments, i.e. school type, school district and student ability. The results indicate there are no statistically significant differences in the two scales among subjects working in different environments. Details of the ANOVA results are shown in Table 4.32 below.

Table 4.32 ANOVA of ENABLE and LIKELIHOOD against the three variables related to working environment

<table>
<thead>
<tr>
<th>ENABLE</th>
<th>School Type</th>
<th>School district</th>
<th>Student Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1.286</td>
<td>.092</td>
<td>2.563</td>
</tr>
<tr>
<td>Sig.</td>
<td>.283</td>
<td>.964</td>
<td>.058</td>
</tr>
<tr>
<td>LIKELIHOOD</td>
<td>School Type</td>
<td>School district</td>
<td>Student Ability</td>
</tr>
<tr>
<td>F</td>
<td>.575</td>
<td>.310</td>
<td>.243</td>
</tr>
<tr>
<td>Sig.</td>
<td>.633</td>
<td>.818</td>
<td>.784</td>
</tr>
</tbody>
</table>

The inferential test, one way ANOVA or t-test, was carried out to scrutinize context beliefs against the personal attributes, namely, qualification in science, qualification in education, gender, age, teaching experience, position in the Chemistry Department and ICT.
competency level. The results indicated there are no statistically significant differences for the six personal attributes. Details of the inferential test results are shown in Table 4.33 below.

Table 4.33 ANOVA/t-test of ENABLE and LIKELIHOOD against the six personal attributes

<table>
<thead>
<tr>
<th></th>
<th>Qualification in Science</th>
<th>Qualification in Education</th>
<th>Age</th>
<th>Teaching Experience</th>
<th>Position in Chemistry Department</th>
<th>ICT Competency Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>2.781</td>
<td>.001</td>
<td>1.283</td>
<td>1.863</td>
<td>1.598 (t-test)</td>
<td>.191</td>
</tr>
<tr>
<td>Sig.</td>
<td>.066</td>
<td>.979</td>
<td>.284</td>
<td>1.863</td>
<td>.113</td>
<td>.902</td>
</tr>
<tr>
<td>LIKELIHOOD</td>
<td>Qualification in Science</td>
<td>Qualification in Education</td>
<td>Age</td>
<td>Teaching Experience</td>
<td>Position in Chemistry Department</td>
<td>ICT Competency Level</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>.924</td>
<td>2.286</td>
<td>.292</td>
<td>.744</td>
<td>-1.189 (t-test)</td>
<td>1.534</td>
</tr>
<tr>
<td>Sig.</td>
<td>.400</td>
<td>.133</td>
<td>.831</td>
<td>.528</td>
<td>.237</td>
<td>.210</td>
</tr>
</tbody>
</table>

From Table 4.34 below, it is observed that respective ENABLE and LIKELIHOOD mean scores for the male subjects (24.66, 35.74) are very similar to those for the female subjects (24.87, 36.13). It is thus possible to say male and female subjects have the similar context beliefs.

In order to confirm that the variable gender is not important here, the two subscale scores were analyzed by t-test. The results, as shown in Table 4.35 below, indicate no statistically significant differences of mean scores between male and female subjects at the .05 level (ENABLE: t=-.201, p=.841, and LIKELIHOOD: t=-.248, p=.804).

Table 4.34 Descriptive statistics of ENABLE & LIKELIHOOD and gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>ENABLE Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>LIKELIHOOD Mean</th>
<th>N</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>24.6582</td>
<td>79</td>
<td>5.28880</td>
<td>35.7467</td>
<td>75</td>
<td>7.95951</td>
</tr>
<tr>
<td>Female</td>
<td>24.8718</td>
<td>39</td>
<td>5.73163</td>
<td>36.1316</td>
<td>38</td>
<td>7.43320</td>
</tr>
<tr>
<td>Total</td>
<td>24.7288</td>
<td>118</td>
<td>5.41549</td>
<td>35.8761</td>
<td>113</td>
<td>7.75534</td>
</tr>
</tbody>
</table>
Table 4.35  *t*-test of ENABLE & LIKELIHOOD against gender

<table>
<thead>
<tr>
<th></th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>T</td>
</tr>
<tr>
<td>ENABLE</td>
<td>Equal variances assumed</td>
<td>.001</td>
<td>.970</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td>.015</td>
<td>.704</td>
</tr>
<tr>
<td>LIKELIHOOD</td>
<td>Equal variances assumed</td>
<td>.716</td>
<td>.399</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td>.722</td>
<td>.397</td>
</tr>
</tbody>
</table>

From Table 4.36 below, it is observed that the four groups of subjects with different ICT competency levels have almost the same ENABLE scores: 23.63 in BIT, 24.91 in IIT, 24.81 in UIT and 23.88 in AIT. Similarly, from Table 4.37, the four groups have diverse mean LIKELIHOOD scores: 31.38 in BIT, 37.07 in IIT, 35.87 in UIT and 33.14 in AIT. Comparative speaking, the LIKELIHOOD scores vary more than that of ENABLE scores.

Table 4.36  Descriptive statistics of ENABLE and ICT Competency Level

<table>
<thead>
<tr>
<th>ENABLE</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error of Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT</td>
<td>8</td>
<td>23.6250</td>
<td>3.58319</td>
<td>1.26685</td>
<td>19.00</td>
<td>30.00</td>
</tr>
<tr>
<td>IIT</td>
<td>44</td>
<td>24.9091</td>
<td>5.92126</td>
<td>.89266</td>
<td>15.00</td>
<td>42.00</td>
</tr>
<tr>
<td>UIT</td>
<td>57</td>
<td>24.8070</td>
<td>5.00514</td>
<td>.66295</td>
<td>15.00</td>
<td>34.00</td>
</tr>
<tr>
<td>AIT</td>
<td>8</td>
<td>23.8750</td>
<td>7.58641</td>
<td>2.68220</td>
<td>16.00</td>
<td>35.00</td>
</tr>
<tr>
<td>Total</td>
<td>117</td>
<td>24.7009</td>
<td>5.43022</td>
<td>.50202</td>
<td>15.00</td>
<td>42.00</td>
</tr>
</tbody>
</table>
Table 4.37 Descriptive statistics of LIKELIHOOD and ICT Competency Level

<table>
<thead>
<tr>
<th>LIKELIHOOD</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error of Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT</td>
<td>8</td>
<td>31.3750</td>
<td>6.56696</td>
<td>2.32177</td>
<td>24.00</td>
<td>39.00</td>
</tr>
<tr>
<td>IIT</td>
<td>42</td>
<td>37.0714</td>
<td>8.20587</td>
<td>1.26619</td>
<td>20.00</td>
<td>56.00</td>
</tr>
<tr>
<td>UIT</td>
<td>55</td>
<td>35.8727</td>
<td>7.63291</td>
<td>1.02922</td>
<td>22.00</td>
<td>51.00</td>
</tr>
<tr>
<td>AIT</td>
<td>7</td>
<td>33.1429</td>
<td>6.14894</td>
<td>2.32408</td>
<td>25.00</td>
<td>45.00</td>
</tr>
<tr>
<td>Total</td>
<td>112</td>
<td>35.8304</td>
<td>7.77486</td>
<td>.73466</td>
<td>20.00</td>
<td>56.00</td>
</tr>
</tbody>
</table>

From Table 4.38, the results of ANOVA on ENABLE with ICT competency level indicate no statistically significant differences in the mean scores among the four groups at the .05 level (F=.191, p=.902). Similarly, from Table 4.39, the results of ANOVA on LIKELIHOOD with ICT competency level indicate no statistically significant difference in the mean scores among the four groups at the .05 level (F=1.534, p=.210). It is thus possible to conclude that the ICT competency level may not be a factor that affects the subjects' context beliefs.

Table 4.38 ANOVA of ENABLE against ICT Competency Level

<table>
<thead>
<tr>
<th>ENABLE</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>17.266</td>
<td>3</td>
<td>5.755</td>
<td>.191</td>
<td>.902</td>
</tr>
<tr>
<td>Within Groups</td>
<td>3403.264</td>
<td>113</td>
<td>30.117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3420.530</td>
<td>116</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Levene statistic = 1.993 & p=.119, the groups can be assumed to have equal variance.

Table 4.39 ANOVA of LIKELIHOOD against ICT Competency Level

<table>
<thead>
<tr>
<th>LIKELIHOOD</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>274.150</td>
<td>3</td>
<td>91.383</td>
<td>1.534</td>
<td>.210</td>
</tr>
<tr>
<td>Within Groups</td>
<td>6435.627</td>
<td>108</td>
<td>59.589</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6709.777</td>
<td>111</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Levene statistic = .682 & p=.565, the groups can be assumed to have equal variance.

To summarize the discussion in this section, it is found firstly that the great majority of subjects have a positive and concerted ENABLE belief, i.e. all the subjects believe that external factors or people would enable them to attain the goal of using ICT for teaching and learning. Secondly, the subjects have a slightly positive yet diverse LIKELIHOOD belief, i.e.
they believe that facilitating factors or people are marginally more likely to be more available to them. In short, the subjects have less positive belief in LIKELIHOOD than ENABLE.

The analyses of ENABLE and LIKELIHOOD against all the other variables, including type of schools, school districts, students' ability, age, gender, teaching experience, position in the Chemistry Department, qualifications in science and in education, and ICT competency, were completed but there are no statistically significant findings.

4.10 Relation of ICT_usage and teacher beliefs

With a view to revealing whether the use of ICT-based tools are related to various belief constructs (i.e. PU, PEOU, ENABLE and LIKELIHOOD), correlation analyses of the ICT_usage were carried out. As shown in Table 4.36 below, it was found that ICT_usage is significantly related to PU ($r=-.293, p<.01$) and also to PEOU ($r=-.277, p<.01$). In addition, it was found that PU and PEOU are significantly related ($r=.699, p<.01$).

Table 4.40 Correlation of ICT_usage and PU & PEOU

<table>
<thead>
<tr>
<th></th>
<th>ICT_usage</th>
<th>PU</th>
<th>PEOU</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT_usage Pearson Correlation</td>
<td>1</td>
<td>-.293(**)</td>
<td>-.277(**)</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.002</td>
<td>.004</td>
</tr>
<tr>
<td>N</td>
<td>109</td>
<td>109</td>
<td>109</td>
</tr>
<tr>
<td>PU Pearson Correlation</td>
<td>-.293(**)</td>
<td>1</td>
<td>.699(**)</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.002</td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>109</td>
<td>121</td>
<td>121</td>
</tr>
<tr>
<td>PEOU Pearson Correlation</td>
<td>-.277(**)</td>
<td>.699(**)</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.004</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>109</td>
<td>121</td>
<td>121</td>
</tr>
</tbody>
</table>

** Correlation is significant at the .01 level (2-tailed).

As shown in Table 4.41 below, it was found that ICT_usage was significantly related to LIKELIHOOD ($r=-.258, p<.01$), but not to ENABLE ($r=-.151, p<.01$). In addition, it was found that ENABLE and LIKELIHOOD are not related ($r=.174, p=.059$).
Table 4.41 Correlation of ICT_usage and ENABLE & LIKELIHOOD

<table>
<thead>
<tr>
<th></th>
<th>ICT_usage Pearson Correlation</th>
<th>ENABLE Pearson Correlation</th>
<th>LIKELIHOOD Pearson Correlation</th>
<th>N</th>
<th>N</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT_usage</td>
<td>1</td>
<td>-.151</td>
<td>-.258(**</td>
<td>109</td>
<td>109</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.117</td>
<td>.007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>109</td>
<td>107</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENABLE</td>
<td>Pearson Correlation</td>
<td>-0.151</td>
<td>0.174</td>
<td>109</td>
<td>122</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.117</td>
<td>0.059</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>109</td>
<td>122</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIKELIHOOD</td>
<td>Pearson Correlation</td>
<td>-0.258(**</td>
<td>0.174</td>
<td>107</td>
<td>118</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.007</td>
<td>0.059</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>107</td>
<td>118</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Correlation is significant at the .01 level (2-tailed).

From the correlation analyses, it is possible to say ICT_usage is related to whether participants perceive ICT-based tools as useful and easy to use, and whether they believe their schools will likely to provide them with good support on the use of ICT-based tools. Putting it another way, a secondary school chemistry teacher with a belief that ICT-based tools will be useful and easy to use, together with the fact that he or she believes that the school will provide good support of the use of ICT-based tools, he or she is likely to be a regular user of ICT-based tools.

4.11 Summary

Based on quantitative data from the survey questionnaire and statistical data analyses, it was found that there is a relationship between:

- Teachers’ age, teaching experience and position in the Chemistry Department
- ICT_usage and PU, as well as ICT_usage and PEoU
- ICT_usage and LIKELIHOOD
- PU and PEoU

Furthermore, ICT_usage was found to be significantly different for the following variables:

- student ability and teachers’ ICT competency level

PU is found to be significantly different among subjects of different gender and teachers’ ICT competency level. Lastly, PEoU was found to be significantly different among male and female subjects.
5. Qualitative Results and Interpretation

5.1 Introduction

This part of the thesis will describe participants' responses to the open-ended questions in the interview protocol (Appendix E), present some relevant interpretations and discuss the meanings and implications with reference to the latest research findings. The purpose of the use of interview, as mentioned in Chapter 3, is first to gather qualitative data so that quantitative data gathered from the survey can be better understood, as well as to collect some additional data not readily available from the survey instrument (Appendix C).

Before the interview, the researcher made telephone conversations with the participants. They were informed on the purposes of the study, the security procedure to be used to protect their personal data, and the logistic arrangement. They were invited to select the most suitable venues like their chemistry laboratory or in a café for the interview. All of them did not pick a café. In addition, they were informed that the language for the interviews could be conducted either in English or Cantonese. All of them selected Cantonese. During the interviews, the researcher paid special attention to participants' emotions and passion about the use of ICT-based tools in teaching and learning, such that a more in-depth understanding about participants' tacit beliefs can be developed.

By collecting and analyzing qualitative data like the most frequently used ICT-based tools, ease of use, experience with ICT in education, ICT-based resources available and context specific factors, it is possible to provide descriptive illustrations that reveal different perceptions about and factors that facilitate or hinder the use of ICT, and the types of alignments or non-alignments (Foley & Ojeda, 2008) of beliefs and practices.
In this part of the study, the researcher had limited time available and access to resources, hence, only a few chemistry teachers were interviewed. In addition, quite a number of chemistry teachers mentioned over the phone that they were not using ICT for teaching frequently and did not have "vivid stories" to tell; hence they did not want to join this study. It is thus considered that a purposeful sampling strategy (Wiersma & Jurs, 2004, p.311) was the most appropriate. In order to produce quality information to make the research findings more comprehensive, the teachers interviewed were strategically selected. In other words, a number of criteria including personal attributes such as gender, teaching experience, teaching level and school type were considered with a view to pick up "maximum variation" (Wiersma & Jurs, 2004, p.312). Details of attributes of the five teachers are listed in Table 5.1.

Table 5.1 The Attributes of Teachers Interviewed

<table>
<thead>
<tr>
<th>Teacher Code</th>
<th>Gender</th>
<th>Teaching Experience (Years)</th>
<th>Teaching Level</th>
<th>School Type</th>
<th>ICT Competency Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Female</td>
<td>5-10</td>
<td>S4-5 only</td>
<td>DSS, girls only</td>
<td>N.A.²</td>
</tr>
<tr>
<td>F2</td>
<td>Female</td>
<td>&gt; 20</td>
<td>S4-5 and S6-7</td>
<td>DSS, girls only</td>
<td>Intermediate</td>
</tr>
<tr>
<td>M1</td>
<td>Male</td>
<td>&lt; 5</td>
<td>S4-5 only</td>
<td>Aided, co-ed</td>
<td>N.A.</td>
</tr>
<tr>
<td>M2</td>
<td>Male</td>
<td>&gt; 20</td>
<td>S4-5 and S6-7</td>
<td>Aided, co-ed</td>
<td>Upper Intermediate</td>
</tr>
<tr>
<td>M3</td>
<td>Male</td>
<td>&gt; 20</td>
<td>S4-5 and S6-7</td>
<td>Aided, co-ed</td>
<td>Advanced (WebSAMS³ manager)</td>
</tr>
</tbody>
</table>

¹ Teachers joining the profession recently are not required to declare or be assessed for their ICT competency levels.
³ Web-based School Administration and Management System or "WebSAM’S" is a computerised system for handling all the administrative work in a school. All secondary (and primary schools) in Hong Kong are required to use the system. The system is developed by the Education Bureau of the Hong Kong SAR Government.
5.2 Perception of usefulness of ICT-based tools

Question 1: What do you think about the usefulness of ICT-based tools in teaching and learning of chemistry?

In the interviews, the above question was raised and all the teachers were encouraged to deliberate on and to express their perceptions of the usefulness of ICT-based tools. From observation, all teachers participated actively and felt free and relaxed and they mentioned a wide range of topics related to their use of ICT-based tools.

In the interviews, all the teachers gave a positive appraisal of the usefulness of ICT in education. Teachers F2 and M3 opined with a definitive tone that “it is not possible not using ICT even for one day”. Teacher F2 said, “numerous administrative tasks like managing student records and teaching with PowerPoint presentations do required the use of ICT”. With all the evidences, it is possible to say with some confidence that in general ICT-based tools are well-received by the teachers interviewed.

After deliberations on the field notes, the raw data from the interviews were analyzed by constant comparative method (Yin, 1994) with a view to construct categories. With reference to all the remarks made by the participants, an inductive approach was used to compare the data. Listed below are four different categories of ICT based tools mentioned by teachers as useful.

a. Presentation

All teachers except experienced teacher M2 said they used quite extensively or very extensively the presentation files developed by the textbook publisher (Aristo, 2008) for teaching and learning. For instance, teacher M3 said he made use of the presentation files
It is very hard to explain how the 'inversion' occurs or the formation of transition state in a bimolecular nucleophilic substitution (SN2). I need to draw a number of diagrams on the blackboard to describe the situation; instead, I prefer to use the reaction mechanism animation in my classes (Teacher M3).

Teachers F1 and M1 also said they would use animations in teaching of topics like atomic structure and bonding (EMB, 2003) at S4-5 level. Hence, it is expected that many other chemistry teachers are also users of animations. This is also in line with the data gathered from the survey questionnaire (Figure 4.3). It should be noted, however, no information has been collected about how the animations are being used. For instance, if teachers used the animations as a teaching aid for expository teaching (Ki, 2000) or teachers ask their students to summarize the changes observed in an animation in writing or describe the changes orally can have quite different impacts on learning. This could be an area for further exploration.

On the sources of animations, all the teachers agreed that the animations provided by the textbook publishers (Aristo, 2008; Jing Kung, 2008) and the Education and Manpower Bureau (Appendix F) are the major sources. It is argued that providing animations to teachers could foster a wide adoption of the tool in teaching and learning process. This is a strategy to reduce the first order barriers of using ICT for teaching and learning (Ertmer, 1999). A post interview evaluation of the animations mentioned by the teachers suggests that they can address one major difficulty in learning science – the connection of macroscopic level phenomenon, sub-microscopic level of explanation and symbolic level of representation (Johnston, 1991). For instance, teachers can introduce why common salt can dissolve readily in water, a complex process to most school chemistry students, with the animation by Chang (2000). The animation can illustrate the dissolution process through the visualization of all the interactions of sodium ions, chloride ions and water molecules in
prepared by the textbook publishers for teachers as the backbones for organizing his lessons. He said with a confident tone that it is very good to have the presentation files as the organizers for the flows of his lessons. Young teacher M1 said an advantage of using presentation files is that he does not need to write chemical equations on the blackboard: a process he regarded as time consuming. Experienced teachers F2 and M2, and young teacher M1 said they would modify the presentation files to fit their preferred sequences of teaching. In addition, all teachers did not hesitate to say they would like to include video clips provided by the textbook publisher (Aristo, 2008) so as to reduce the time required for doing some lengthy experiments, and at the same time provided some practical experiences for their students. This finding is resonant with the data gathered from the survey questionnaire (Figure 4.3): presentation is the second most frequently used ICT-based tool (and word processing is the most frequently used one). This finding is also similar to the finding by BECTA (2007, p.26), “the main uses of ICT across the curriculum were word processing, internet access and presentations”. Furthermore, this finding is also consistent with the “tool use” reported from the meta-analysis done by Kozma (2003). The high frequency of use of presentation will lead us to think whether teachers are pretty comfortable with what Tapscott (2009) suggested “the model of education that still prevails today was designed for the Industrial Age ... the teacher who delivers a one-size-fits-all, one-way lecture...” (p.122) and “teaching mode I” (Baumgartner & Heyer, 2007). Do teachers actually think about the use of constructive pedagogy, which is listed as one of the effective techniques for the organization of learning (Microsoft, 2006)?

b. Animation

Experienced teachers F2, M2 and M3 said they would use animations in teaching of organic chemistry reaction mechanisms (EMB, 2006) at S6-7 level.
an appropriate sequence. Hence, all the animations mentioned above can be very good reference materials for learners with an assimilating learning style (Kolb & Kolb, 2005).

c. Computer-mediated Communication (CMC)

All teachers reported that they made use of computer-mediated communication (Thurlow, Lengel & Tomic, 2004) tools like email or electronic notice board of the intranet system (Warschauer, 1998) for enhancing students’ learning. Teacher M2 preferred to post information required for learning with the notice board, and students were trained to read the notice board from time to time. As an example, he would put up details of the coming practical based project and ask his secondary six students to plan their own experiments. He would also respond to problems posted by students on the notice board. All students could see the problems raised by their peers, and the solutions or hints put forward by the teacher. He added that he preferred the many-to-many communication mode, as he believed that this practice could help all students to learn from their peers. However, teacher M1 said his students preferred to use emails for one-to-one communication. Similarly, teachers F1 and F2 said they would make use of emails to solve problems encountered by “home study” students, i.e. students preparing for public examinations. Just like M1, teachers F1 and F2 mentioned that their students preferred the one-to-one communication mode, i.e. using emails for private communications. With all the examples cited, teachers are using a multiplicity of CMC tools to facilitate students to learn. Among all the tools described, many of them are indeed asynchronous communication tools (Ashley, 2003; Karsenti, 2007). The reasons why teachers described the asynchronous communication tools as useful are probably that they can:

1. facilitate communication between teachers and students (Kozma, 2003) at different times and at different places as a supplement to face-to-face discussion during school hours, and
2. offer one-to-one or many-to-many communication modes that suit the requirements of teachers and students with different needs.

How asynchronous tools can enhance the quality of learning will be an interesting area to explore in the future. However, it was perfectly clear that different forms of communication between teachers and students can facilitate the learning beyond the classroom walls.

I frequently post challenging questions using the NoticeBoard system in my school intranet (i.e. a CMC tool). My students, and in fact all students in the same level of study, are welcome to respond to the questions. After some time, I will post the solutions to the questions. Students with problems can always approach me for advice (Teacher M3).

It is correct to say students would spend more time on learning tasks, and hence gains in achievement are expected among these students. Nevertheless, the teachers appeared to have less strongly held belief about the importance of the use of CMC tools for enhancing students' learning when compared to presentation.

d. Interactive Whiteboard

In the interviews, all teachers said they had several interactive whiteboards (IWB) installed in their respective schools, and training courses on how to use the IWB were provided. Without territorial wide quantitative data, it is hard to speculate on how widely IWB are used for teaching and learning in local secondary schools, or how IWB are being used in different subjects.

With a brief review of the survey questionnaire (Appendix C), it is disappointing to find the IWB had not been included in the survey questionnaire. This is a limitation of this study and it is also true for much ICT research: it is hard to keep up with the rapid pace of development of technology, especially in hardware. The so-called Moore's Law and Moore's
Second Law (Wikipedia, 2009), though lacking academic rigour when compared to other laws in physical sciences, can be a reference here. Fortunately, this study adopted a less-dominant design making the exclusion of the IWB in the questionnaire not a serious deficit. This study can at least include teachers’ views on the use of the IWB.

Teacher F2 mentioned that she had completed a school-based hardware vendor provided training course on the use of the IWB, and completed two assignments on the use of the IWB for teaching and learning. However, she had not made use of the IWB for teaching of chemistry yet. As a pragmatic practitioner, she said the use of PowerPoint with an LCD projector was much easier to operate than an IWB. She further said that it would be wise to do a cost-benefit analysis before making a decision to use the IWB for teaching. It is thus questionable whether the training provided did precisely address the key aspect required: training in the use of IWB for whole class teaching (Moss et al., 2007, p.119). She further mentioned the IWB fits teaching and learning at the junior secondary level more, as junior students need more interactions in their lessons.

I believe that students in junior secondary need more interactive and lively pedagogies. However, most of my students are in senior forms, they have high concentration and are preferred to have more content coverage in a short period of time. Hence, I do not think IWB will be a very useful teaching tool to me for the time being (Teacher F2).

Teacher M3 shared a similar view with teacher F2 on the use of an IWB, and he had not yet made use of the hardware for teaching and learning. Teacher M2 was the only teacher who had made use of an IWB for teaching the chemistry specific genre (Robinson, 2008). He said he used an IWB to demonstrate to his students how to organize different paragraphs of a piece of writing in the correct order. All the students were then asked to carry out a similar class exercise, and then complete another writing task. A post interview literature
search could locate no local study on the impact of the IWB on teaching and learning, it is not possible to state whether the IWB has a genuine and positive impact on teaching and learning. The UK study by Condie et al. (cited in BECTA, 2007) is a good reference on the effectiveness of the use of the IWB for teaching and learning.

... after examining a considerable number of studies, large and small, relating to the impact of IWB, all of them reported universally positive outcomes, particularly when they were used in conjunction with other technologies ...

On the other extreme, another study concluded that "the impact of IWB on pupils' attainment is relatively small" (Higgins, 2003). Similarly, according to the study by Smith, Higgins, Wall and Miller (2005),

although the literature reviewed is overwhelmingly positive about the impact and the potential of IWB, it is primarily based on the views of teachers and pupils. There is insufficient evidence to identify the actual impact of such technologies upon learning either in terms of classroom interaction or upon attainment and achievement.

With the diverse views on the IWB, teachers should be encouraged to examine whether this particular ICT-based tool is useful for teaching and learning. Just as what teacher F1 said,

I learnt from the IWB training course that an IWB can be used to record all the classroom interactions in a digital format and can be stored as electronic learning units. I believed that these units will be useful to students who were absent from school for various reasons, and also these units could be reviewed by all students for a more in-depth learning.
In a conference presentation, Nys (2008) reported the inventor of the chalkboard deserves to be ranked among the best contributors to learning and science, if not the greatest benefactors of mankind. Whether the IWB becomes the next system that dominates the central position of a classroom is yet to be confirmed. Will the IWB follow the same footsteps of the motion picture and the radio (Chapter 1) - being claimed to be able to revolutionize the educational arena but eventually becomes just another "white elephant"?

Academics also put forward questions like:

- The capacity of the IWB to transform or accommodate existing pedagogic practice.
- Can the IWB act as a catalyst for the development of interactive pedagogy?
- Can the IWB enhance learning through the use of multimodality?
- Can the IWB enhance the pace and speed of learning and teaching?

(Moss et al., 2007)

The use of the IWB can indeed be an area that is worth more in-depth scrutiny in the future.
5.3 Perception whether ICT-based tools are easy to use

<table>
<thead>
<tr>
<th>Question 2: Do you think ICT-based tools for teaching and learning of chemistry are easy to use?</th>
</tr>
</thead>
</table>

In the interviews, the question was raised and all the teachers were encouraged to deliberate on and to express their perceptions on the ease of use of all the ICT-based tools. All teachers claimed they were very “comfortable” with the use of office automation software like word processing and presentation. They said the tools were used to respectively discharge routine administrative tasks and to deliver their lessons. However, they were using spreadsheet less frequently. This piece of information confirmed the findings from the survey questionnaire (Figure 4.3).

Using the same data analysis techniques mentioned in Section 5.2, four different categories of responses related to ease of use emerged.

a. Tools for Drawing Molecular Structures

Teacher F2 mentioned that she found software tools for drawing molecular structures (e.g. ChemDraw or ISIS Draw) very difficult to use, and the operation of such software tool was quite different from the other ICT-based tools. To get around the issue, she used the drawing tool provided in the word processing software, and she built up a library of drawings for her personal use. She now possessed a library of drawings that addressed all her own need (Figure 5.1).
She cited another difficulty in the use of ICT in the interview, "I could retrieve a drawing from the Chemistry Clipart (ED, 1997), however, I could not assemble the drawings of several pieces of apparatus together the way I needed. There were no training courses on the use of this tool, and I could not locate the manual to solve my problem".

Teacher M3, had a quite different view from teacher F2 on the use of tools for drawing molecular structures, he suggested that the drawing tools were very easy to use.

I am now using ChemDraw 8. The software was offered to me free of charge by the CambridgeSoft. The software is indeed very easy to use. For instance, you can draw a long chain of hydrocarbon of 16 carbon atoms by "click, drag and release". (Teacher M2).

On setting examination papers, he would use the drawing tools. He said the difficulty mentioned by teacher F2 could be due to a lack of training. He added that the training required to use the software properly would not be a hard one. Even though there might be difficulties with some aspects, trial-and-error could solve the problems. In the interview with teacher M2, he shared the view of teacher M3 in this aspect: the drawing tool was easy to use. Teachers F1 and M1 did not need to use molecular structure drawing software as teaching the S4-5 chemistry curriculum did not involve complicated molecules or reaction mechanism. It is thus speculated that the teachers teaching the S6-7 level chemistry will have training needs different from those teaching the S4-5 level chemistry. In addition,
teachers adopting different chemistry curricula will need training on the use of different ICT-based tools. It is argued here that a training agency should refrain from providing a one-size-fits-all training course for the use of ICT for all the teachers. Instead, all training courses of the use ICT-based tools have to be designed for a very specific group of target participants, so that the courses could meet as fully as possible the expectations of all the intended participants. Perhaps, it will be worthwhile to explore whether the peer tutoring practice (UNESCO, 2003; Russell & Bradley, 1997) is an effective and not a resource-intensive means to address diverse training needs. According to UNESCO (2003), peer tutoring is "a relatively common approach in classrooms of cultures around the world, and it is effective even when teachers have little ICT skill and knowledge".

b. Office Automation Tools

Except with the use of drawing tools as suggested by one teacher, all the teachers said the use of general ICT-based tools posed little challenges to them. As an example, all the teachers said they could insert a video clip supplied by the textbook publishers into a presentation file. They said the process was not difficult. This is in agreement with the findings from the survey instrument: word processing and presentation tools were the most frequently used ICT-based tools (Figure 4.3). Teacher M3 opined:

Microsoft Office Software is so ubiquitous and so popular in Windows based computers, it is not possible to avoid using the software for even one day. In addition, I could not think of a reason for avoiding the use of the software, it is indeed very user friendly and it has a low learning curve.

In the interviews, teachers F1, F2, M1 and M2 reported that they need to use spreadsheet only once in a while. They added that they have to complete only very limited pieces of "data crunching" tasks. According to what teacher M3 said, nearly all routine data
management or assessment scores manipulation can be handled by the WebSAMS or the teacher assessment scheme (TAS) software (HKEAA, 2008). This makes spreadsheet not a really essential ICT tool for chemistry teachers.

Teachers had mentioned nothing about student's use of spreadsheet. Should students be encouraged to draw a graph by using spreadsheet or resort to "graph paper and pencil"? Should students be encouraged to do complex data analysis with spreadsheet? Sinex (2009) argued that "spreadsheets, such as Excel and OpenOffice Calc, have found extensive use in mathematics and the sciences for data analysis, simulations, and concept illustration at all levels; there are many examples in chemistry". The use of spreadsheet can be a great but underused ICT tool for teaching and learning of chemistry.

c. Constructivist-oriented Tools

Teachers M2 and M3 recalled their experiences about the use of the web-based collaborative learning tool – Knowledge Forum (KF, 2009) a few years ago. The tool is reported to be capable of "providing students and teachers with a unique collaborative space in which to share ideas and data, organize course materials, analyze research results, discuss texts, and cite reference material" (KF, 2009). Teacher M2 said he and his students used the old version of the software. The operation of the client programme was not difficult, but the software did require a server with great computation power in order to achieve good responses. In the collaborative learning project a few years ago, his students felt frustrated with the use of the client programme, because they did not get speedy responses from the server. Furthermore, the client programme did not support the use of traditional Chinese characters for communication, hence students had to use a second language for discussion. Teacher M2 considered the said limitations as barriers to the use of ICT for teaching and learning. In order to get around the difficulties encountered, teachers M2 and M3 decided to
abort the use of Knowledge Forum for their collaborative learning projects. With a view to continue to use collaborative learning strategies for learning, they decided to develop a web-based collaborative learning tool for the purpose. The development is still on-going.

Teacher F1 and F2 said they had not even thought of a learning scenario that her students could use in a collaborative manner, and they had not been introduced to such a tool. The other teachers had no experience with any constructivist based learning tools. In essence, the use of constructivist collaborative learning ICT based tools has been at most “sporadic”.

On the use of software ChemSense (Appendix F), all the teachers interviewed had no acquaintance with the tool. They said the software was not formally introduced, and there were no training courses available. The above description on Chemsense is almost fully applicable to the strategy Webquest (Dodge, 2001). The strategy had been introduced to teachers through a number of 6-hour workshops, a number of local ICT in education conferences and the effort of a local university (CUHK, 2007). However, all the teachers interviewed had limited knowledge about and had not implemented the strategies in their classrooms.

d. Authoring Tools
As mentioned in the survey results in Chapter 4, authoring tools had been the second least frequently used ICT-based tool for learning and teaching. Teachers F1, F2, M1 and M2 had not used the software. Teacher M3 was the only teacher interviewed who had experience with “Authorware”. However, he had not used the authoring tool for at least one or two years for the reasons: “the products are not attractive” and “a great deal of effort and plenty of time are required to produce a simple courseware”. It is simply too hard to use the tool and the coursewares produced are not appealing to students.
A post interview literature search revealed that a chemistry tutorial package created by Authorware, namely “Air Pollution”, was published by the then Education Bureau in 1997. The package was intended to be used by Advanced Level chemistry students for self-learning. As teachers M2 and M3 said, the package had only limited impact on the teaching and learning of chemistry, and there was no further development on the package.

The software publisher (Adobe, 2007) has discontinued the development of “Authorware” in 2007 as demand continually declined. The software developer also announced that no compatible product would be developed as a replacement for “Authorware”. Putting the information together, it is possible to say the “Authorware” is no longer a useful tool in the pedagogical repository of teachers.
5.4 Experiences with ICT in Education

| Question 3: | Please describe your experiences of ICT in education gained in study at secondary school, undergraduate and postgraduate levels. Does it affect your practice of teaching? Why and why not? |
| Question 4: | Please describe your experiences of ICT in education gained in courses offered in the ITED project, EDB. Does it affect your practice of teaching? Why and why not? |

In the interviews, the above questions were raised and all the teachers were encouraged to deliberate on them and to respond. As mentioned in Section 5.3 above, all teachers claimed they were very "comfortable" with the use of office automation software, especially word processing and presentation. However, they learnt the operation of these tools in different ways. For instance, teacher M3 had a personal interest in computing and learnt how to use office automation software by self-learning through trial-and-error for many years, however young teachers F1 and M1 took formal courses on computer literacy during their undergraduate study. The diverse experiences with ICT among teachers may had some influence on teachers' beliefs about teaching and learning with ICT.

Using the same data analysis techniques mentioned in Section 5.2, three different categories of responses related to teachers' experiences with the use of ICT in education emerged.

a. Pre-service experiences with ICT

Both teachers F1 and M1 had less than ten years of teaching experience. They recalled that they had to attain a certain level of ICT literacy before they could graduate from their undergraduate studies. As an example, a local university offered a 3-credit course namely "Foundations to Information Technology" and a 2-hour "Information Technology Proficiency Test" for her undergraduate students (HKU, 2009). The said course provided students with a range of basic IT knowledge and concepts, and enabled students to learn how to use some software packages, do web publishing and handle SPSS. However, teachers F1 and M1
remarked that they had been quite competent in using the software through day to day use
(Anderson, 2006, p.35) for different purposes. Teacher M1 mentioned that he was using
presentation software occasionally during his advanced level study, and quite frequently in his
undergraduate study. Teacher F1 also reported a similar experience. In short, they look
like "digital natives" (Prensky, 2006) and they have a lot of pre-service experience with ICT.

Teachers F2, M2 and M3 have more than 20 years of teaching experience. They remarked
that during their study at the secondary and at the undergraduate level, their teachers had no
access to computers for teaching and learning. In that period, computers were used for
teaching computer science and for handling administrative tasks only. Computers were
perceived as a special and delicate piece of equipment for non-routine use only. Teachers F2
and M2 mentioned that they used PDP-11 for learning computing in their undergraduate
study.

During my undergraduate study, I had to attend a computer course
"FORTRAN programming" using PDP-11. I forgot what I ever did
with the computer. Also, during my study for the post graduate
certificate in education, I learned nothing about the use of computer
for teaching (Teacher F2).

This is understandable as personal computers have only been widely used for teaching and
learning in secondary schools and in undergraduate courses for about ten years (ED, 1998).
Only quite recently, a large number of personal computers have become accessible for
teaching and learning and the target for “using right Technology at the right time for the right
task” is being envisaged (EDB, 2008). The remarks by teachers on the early days of the use
of computers are in line with what Cuban argued, "... computers are hard to master, hard to
use, and often break down; therefore, investing effort into having students use them
frequently is hardly worthwhile, and we should not expect many teachers to make this effort"
Based on a large scale survey in the United States, Becker (2000) precisely pointed out, "... with the continued exponential increase in the technical capacities of computer and network technologies, make Cuban's assertions of minimal impact likely to be out-of-date in the near future". This study also confirms that computers are in fact a ubiquitous and essential tool used every day, and computers are not hard to use any more.

Teacher M3 explicitly pointed out that he has been using computers at work and at leisure for more than 20 years. His first computer was an Apple IIe, which was acquired after he joined the teaching profession. He had tried a large number of computers and software packages. In short, he had a rich experience with the computer, but his experiences with ICT were gained in the "in-service" period. Similarly, experienced teachers like F2 and M2 reported that their own school ICT experiences did not have any impact on their beliefs about the use of ICT for teaching and learning. It is speculated that the ICT skills of most experienced teachers were gained almost exclusive during the "in-service period". Roughly speaking, all the experienced teachers interviewed could be classified as "digital immigrants" (Prensky, 2006).

With reference to experiences with ICT by the two groups of teachers (i.e. experienced and young), it is deemed appropriate to suggest that they require quite different areas of training. Young teachers, especially those very much like "digital natives", require less or no training in the operation of computers, and software like office automation tools and browsers. The said training will be useful to some experienced teachers, however.

Downes et al. (2001) proposed a framework that identified goals for the integration of ICT into classroom practices. According to Prestridge (2009), the three goals are:
A. Teachers are using ICT for the attainment of skills such as the use of office automation tools.

B. Teachers are using ICT as a tool to achieve the existing curriculum targets, with ICT considered as "adding-on" while maintaining the existing pedagogical approach (i.e. teaching mode I suggested by Baumgartner and Heyer, 2007).

C. Teachers are using ICT in a way that transforms existing pedagogical practices, for example, a thoughtful, responsive and futures oriented teaching practice will be used in the classroom.

Based on the three goals and the abovementioned findings related to all the five teachers' experiences with ICT, it is clear that all teachers interviewed especially the young ones, do not require training that target for goal A. Under the notion of the need of "paradigm shift" (ED, 1998), it is argued that all teachers should now be provided with professional development programmes that target for goal C, rather than A or B.

b. In-service training on the use of ICT

On the type of training courses provided, all the teachers mentioned they would like to attend courses offered in the ITED project (ED, 1998), especially those courses designed for enhancing the use of ICT in teaching and learning of chemistry. Experienced teachers, especially M2 and M3, agreed that they would like to attend training courses on using innovative ways in teaching and learning of chemistry. All the teachers said however there were only few courses focused on teaching and learning of chemistry available. Among all the teachers, only M2 could cite the last course related to the use of ICT in teaching and learning of chemistry which he attended was held almost two years ago. In short, the training courses designed to meet what teachers expected were not frequently offered.
With the information on the daily use of ICT provided by the teachers, it is reasonable to argue that the initial teacher enablement exercise (ED, 1998) has been fully fulfilled (goal A mentioned by Prestridge, 2009), however, the subject specific ICT training needs have not been sufficiently addressed (goals B and C mentioned by Prestridge, 2009). In more precise terms, it appears that all the teachers interviewed have attained some high level of ICT competency, in particular, the use of office automation software. Nevertheless, there is only limited evidence to justify the conclusion that teachers have sufficient training in how to use ICT for teaching and learning in their own subject area, chemistry.

Last on training, all the teachers mentioned that they need training on the latest hardware tools like IWB or software tools like blog for learning (Richardson, 2009; Wikipedia, 2009). All teachers (young and experienced) will need the same kind of training, i.e. from operating of to using the tools for various pedagogical purposes.

c. Preferred mode of professional development

As said earlier, teacher M3 has a rich experience with the computer. He mentioned that his colleagues asked him to solve different computer related problems up to two or three times a day, and he was willing to help fellow teachers to solve problems. His support for colleagues ranged from keying in assessment data to extracting and analyzing information from the WebSAMS system. He has been also working with his physics colleague to manage a lot of ICT facilities in his school. Based on his rich ICT experience, he was appointed as the ICT trainer in his school a few years ago.

In a further discussion on training, teacher M3 opined that the practice of hiring external trainers to his school to deliver IT courses for his fellow teachers had been less than fruitful.
He explained that most of the external trainers he encountered had weak presentation skills when compared to his fellow teachers, and did not have a good understanding of the specific needs of different teachers in his school.

Russell and Bradley (1997) examined teachers' computer anxiety and preferred strategies for professional development using a sample of 333 teachers in Australia. They reported that teachers, among the six different strategies examined, preferred to have "opportunities to learn by observing skilled colleagues working with computers" and "computer training programmes conducted by an external consultant at school". The first strategy is resonant with the current practice mentioned by teacher M3 in his school. However, the second strategy is not in line with the experience reported by teacher M3.

Teachers F1 and F2 reported that their ICT coordinator and laboratory technician did provide them with very good support on the use of ICT. In addition, their fellow male chemistry teacher also facilitated them in many aspects related to ICT. The findings from M3, F1 and F2 are in line with those from Russell and Bradley (1997).

Russell and Bradley (1997) also put forward a finding related to peer assistance. They saw "peer assistance as more likely to be supported if the computer coordinator was not also a full-time teacher, as asking peers for help was sometimes seen as creating unreasonable demands on colleagues". The argument is reasonable in the sense that the computer coordinator or peer assister will definitely have a higher workload on top of that related to routine teaching and learning. In order to use the peer-assistance strategy, it is necessary to provide the peer assistant with "time release".
With reference to information provided by teacher M3, it is conjectured that there are quite a number of chemistry teachers in the territory with ICT competency similar to that of teacher M3. Could these teachers be identified and invited to provide training courses about the use of ICT for teaching and learning of chemistry to fellow teachers? Would these teachers be good peer trainers? Would this be a good strategy to further enhance the quality of teacher enablement exercise (ED, 1998), especially for subject based training courses?
5.5 Factors that facilitate or hinder the use of ICT for teaching and learning

Question 5: Please describe how people (e.g. fellow teachers, administrators, laboratory technicians, students, parents, etc.) have either helped or hindered the use of ICT in teaching and learning of chemistry.

Question 6: Please describe how the physical environment (e.g. classrooms, laboratories, availability of software, equipment, etc.) have either helped or hindered the use of ICT in teaching and learning of chemistry.

Question 7: How do you deal with challenges and obstacles in the use of ICT in teaching and learning of chemistry outline in questions 5 and 6 above?

In this study, one of the aims is to scrutinize how teachers’ beliefs about ICT are linked to various contextual factors (research question 3). In more concrete words, data has to be gathered to determine whether or not the working environment influences teachers’ use of ICT for teaching and learning. Hence, interview questions 5, 6 and 7 were used to gather the said information. After all the interviews, four factors emerged as being grouped into the following aspects: people or human factor (ITED, 2008) and physical environment (including the availability of resources). Towards the end of this section, how teachers handle the challenges related to the use of ICT-based tools will also be reported.

a. People – friends or foes?

In the interviews, all the teachers reported that their school principals did facilitate their use of ICT for teaching and learning. Their principals provided support to installation and updating of computers, LCD projectors, different servers and intranet systems. In addition, WIFI network was also installed in addition to the Ethernet. The principals also took the lead to install several IWBs and provide training courses on how to use them (Section 5.2d). Teachers regarded their principals as one of the success factors in the use of ICT for teaching and learning.
Besides their principals, teachers were asked whether their fellow teachers were supportive to their use of ICT for teaching and learning. Teachers F1 and F2 said one of their chemistry colleagues helped them to learn how to use tools for creating molecular drawings (Section 5.3a), though she had not quite mastered the skills required and she was still using the drawing tool from the word processing software. Teachers M1, M2 and M3 responded with confidence that they did not find help from colleagues essential. The interpretation is that teachers have reasonably good ICT competency or a very low level of computer anxiety. This is especially true for teacher M3. As reported by Jimoyiannis and Komis (2009, p.168), there are a few studies like those of Russell and Bradley (1997) who found female teachers had a greater degree of anxiety. Lee (1997) found female teachers were less confident computer users, and the European Commission (2007) noted that the gap between males and females is even wider as far as the use of the Internet is concerned. In addition, Jimoyiannis and Komis (2009, p.168) found that male teachers in general are positive about ICT in education whereas female teachers are neutral or negative. Also from interviews, especially in the case of M3's intra-school ICT tutor role, it was revealed that informal peer support practice is operating through day-to-day question and answer is a possible means of support.

Teachers F1 and F2 gave very positive appraisal to their male laboratory technician, and they described him as their "data logger instructor". They agreed that the laboratory technician is a "very good computer problem solver". Teacher F2 said "he will teach me how to operate the data loggers, and then I will instruct my students accordingly". Teachers F1 and F2 also gave a positive appraisal for their ITEDs staff in supporting the use of ICT in education. For example, they could provide very good support to solve technical connection problems, or to replace the faulty bulbs in LCD projectors. On the contrary, teachers M1, M2 and M3 considered they did not need to seek help from their laboratory technician. They said the laboratory technician focused on tasks related to daily student practical work or "wet
chemistry". Teacher M3, just like teachers F1 and F2, gave a very positive appraisal of his ITEDs staff. They provided very good support for the operation of school networks and servers, solving software problems and handling miscellaneous maintenance tasks like replacement of faulty bulbs in LCD projectors. Teacher M3 also said the ITEDs staff greatly facilitated the operation of various data crunching tasks like computerized questionnaire data analysis and post-test item analysis. Technical support from laboratory technicians and ITEDs staff appears to be essential for teachers to optimize their use of ICT based tools for teaching and learning. Teachers’ workload has been greatly reduced with the support from ITEDs staff.

On the role of students, teachers F1 and F2 agreed that their students had reasonably good ICT competency and said they could handle most of the tasks required to learn with ICT, but they were not fluent in webpage authoring. They said their students are competent users of social software like MySpace or Facebook (Dalsgaard, 2009), but not yet for learning purposes. Anyway, teachers F1 and F2 considered their students as a success factor in their use of CMC tools. Similar arguments were also put forward by teachers M1, M2 and M3, except they agreed that their students have high ICT competencies. They added that their school “IT prefects” (Fong, 2001) did provide support.

All the teachers said their uses of ICT did not involve any parent. Hence, the role of parents in this study was very limited.

To conclude, the people in the schools involved in this part of the study contributed and provided a positive support for the use of ICT for teaching and learning. Literally, all teachers agree that no human factor (ITED, 2008) hindered their uses of ICT. But it should be remembered that some human factors may be operating in other schools not participating in
this study. This is one area that can be further explored in order to have a holistic picture of
ICT usage.

b. Physical Environment

Beside the human factor discussed above, this study also attempted to solicit more
information, particularly related to ICT use, about the working environment of teachers. A
post interview literature search about the ICT infrastructure from the school's website of
teachers F1 and F2 revealed the following details.

The teaching block includes thirty-four classrooms, six science
laboratories, a school library, a multi-media self-access learning centre
(MMLC), an information technology learning centre (ITLC), ... a
video-broadcasting studio and a micro-teaching room, ... a Computer
Assisted Learning (CAL) Laboratory, ... Classroom of the Future ...
(Source: School A's website)

A similar search on the school's website (teachers M1, M2 and M3) revealed the following
details.

To provide the best learning environment, many facilities, on top of
the standard provision, have been installed. They comprise ... three
Multi-Media Learning Centres, two Computer Rooms, ... The Broadcast
Room is an excellent training ground for budding journalists and
anchors to be given free reins to show their creativity and flair for
English and Putonghua on Campus TV ... All classrooms and special
rooms have been equipped with LCD projectors and desktop
computers networked and linked to the Internet. In addition, through
the Quality Education Fund Projects, the cutting edge of information
communication technology and multimedia capabilities have been
brought to bear on the teaching of various disciplines ...

(Source: School B's website)
With the data gathered from the teachers and from the schools' websites, it is possible to state that the two schools do have a very good ICT infrastructure. They have more than hundreds of networked and internet-ready computers, a good supply of LCD projectors in ordinary classrooms, and a number of special rooms with a large number of computers for teaching and learning purposes. The teachers interviewed should therefore have no problem in delivering a lesson in which all students could participate in hands-on ICT-based learning tasks simultaneously. However, teachers F1 and F2 reported that they had never thought of organizing a whole class of 40 students to sit in front of computers to learn. Teacher M3 shared a similar view that he had not organized students to use computers for learning. It is thus argued here the teachers do not believe that personal or social constructivist oriented paradigms are useful. Hence they still prefer to operate the transmissionist-oriented paradigm (Gobbo & Girardi, 2001).

For more specific subject-based ICT tools, teacher F2 raised her concern that defective data loggers were not replaced. She pointed out that because of the decreasing number of functioning data loggers, the number of students in a group was increasing. She had been contacting fellow teachers about how to solve the problem and get extra funding to replace the broken data loggers. For teacher M2, he mentioned that he was lucky and obtained extra funding from his school to replace all the obsolete data loggers (i.e. those using serial connectors to interface with computers). Teacher M2 said they had acquired around ten netbooks and data loggers with USB connectors. He added that the data loggers were good enough for most experiments, and the data loggers could be used in different field work for learning science. However, he also reported that for teaching and learning of chemistry, there were only a limited number of opportunities to make use of data loggers; and there

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*The term "netbook" refers to a small laptop computer with about 9-10 inch LCD display unit. Netbook is designed primarily for web browsing and communication purposes only.*
were more opportunities in physics. The survey instrument also indicated that the data logger had a frequency index of around 2 out of 5, and data logger was ranked as the ninth most commonly used ICT-based tool (Figure 4.3). A document analysis of the current chemistry curricula (CDC, 2003a) indicated only a few experiments had to be completed with data loggers:

- pH titration curves (pH sensor)
- characteristics of discharge of different dry cells (voltage and current sensor)
- a study of factors affecting the rate of reaction of metal and acid (absolute pressure sensor)

It is also necessary to point out that some of the experiments listed above could also be completed with traditional instruments like a pH meter or colorimeter. In essence, there are only a small number of experiments for which the data logger is a must.

With all the information, it is known that the use of data loggers for teaching and learning of chemistry is not a widely adopted practice. The phenomenon can be related to

- the existence of "first order barriers" (Ertmer, 1999) – the hardware availability is still an issue
- the subject nature of chemistry – only a few practical related learning tasks have to be completed with data logger
- the competition with traditional instruments like the pH meter and colorimeter – they are simple, easy to use, accessible, and can produce the data required with reasonably good accuracy

To conclude the discussion about the physical environment, it is possible to say most of the secondary schools in Hong Kong do have a very good ICT infrastructure. Teachers can make use of ICT for teaching and learning without hindrance. On the contrary, the access to subject specific hardware like data loggers is still limited. In other words, there are still first order barriers at the subject level, and more support in this aspect is required.
c. Resource Materials

As reviewed from the interviews with all the teachers, all of them reported that the local textbook publishers produced, on top of the textbooks, a range of resource materials to support various teaching and learning aspects (Aristo, 2008; Jing Kung, 2008). The resource materials were distributed to schools free-of-charge. A post interview document analysis on the resource materials published by a local chemistry textbook publisher (Aristo, 2008) revealed that many of the resource materials are ICT-based, for example, presentation files, animations, digital video clips and digital photos are provided. This facilitates the adoption ICT-based pedagogy. The teachers interviewed said they frequently made use of these resource materials, in particular presentation files, digital video clips, and less frequently animations. This is also evidenced from the high frequency indexes of the use of presentation and animation (Figure 4.3): they are ranked the second and the fourth most commonly used ICT-based tools (with word processing and spreadsheet ranked the first and the third). It is reasonable to say that teachers are encouraged to use ICT-based tools in their classrooms with the resource materials provided by the local textbook publishers. However, it is argued that the use of the aforementioned resource materials will likely encourage teachers to adopt a transmissionist-oriented paradigm (Gobbo & Girardi, 2001). In other words, teaching with the presentation files will encourage a more teacher centered approach, rather than a collaborative student centered one. There are views from different sources that presentation with PowerPoint is not the most effective tool for teaching and learning. Kennedy (2004) argued that, for higher education, "truly effective lecturers intersperse their talks with brief periods of problem solving, planned student-to-student or student-to-faculty interactions, or other planned activities that reengage students or allow them to apply what they are hearing". Will these arguments be applicable to teaching and learning in secondary schools?
Besides the presentation files, digital video clips and photos and animations, a local textbook publisher (Aristo, 2008) also provides teachers and students with an online test system. The system allows students to check their knowledge and understanding using different pre-designed online tests, and allows teachers to manage and deliver tests to their own specific groups of students. According to teacher F2, the online test system is quite comprehensive, and provides teachers with the following functions: login control, user account maintenance, test generation and management, test results analysis and continuous evaluation. Students need only a browser and an Internet connection to go to the publisher’s website, select the test of interest, input user name and password and complete the test. For the “digital natives” (Prenskv, 2006), the online test system is quite user friendly and easy to operate. This should account for to certain extent the reasonably high frequency index of the use of drill and practice (Figure 4.3). However, teachers F1 and F2 described explicitly that the content in the online test system as being inaccurate, and they decided not to use the system at all. Teachers M1, M2 and M3 did not use the online test system. They said they could achieve the same goals by using OCR machines with the support from their ITEDs staff (ITED, 2008) to do post-test item analysis. They did not need to mark the objective questions based scripts at all. In particular, teacher M2 said he could pick up common misconceptions among students based on the item analysis results, and re-focused his instruction on the misconceptions. The use of OCR technology is considered to be a good ICT practice which is widely adopted in many public examination agencies, but the practice is not fully explored by most of the teachers in daily classroom teaching.

Finally, teachers are also provided by a local textbook publisher (Aristo, 2008) provided teachers with a collection of questions from a question bank. The question bank has
content fully compatible with the most popular word processing software. Teachers can build a number of quizzes, tests or examinations with a minimum amount of effort. In addition, the publisher (Aristo, 2008) developed and distributed a software tool called "Question Creator" which further reduced teachers' workload required in draft properly formatted assessment tasks to be administered in a paper-and-pencil format. Given the provision of a handful of ICT based resource materials, all the teachers interviewed agreed that ICT is essential for teaching and learning.

Teachers can be encouraged to adopt more ICT based pedagogy by providing different ICT based resource materials. However, care is needed when providing different types of resource materials. As an example, if a teacher attempts to provide his or her students with learning experiences using a social constructivist strategy, it is appropriate to keep the use of presentation files to a minimum. It is more appropriate to use resource materials that encourage constructivist pedagogy. ICT-based learning tools like "e-group" and "Knowledge forum" should be used more frequently.

d. Handling challenges related to the use of ICT-based tools
As mentioned in the above discussion, teachers interviewed encountered only small challenges and hence this section is relative brief. For instance, teacher M2 outlined an incident when he wanted to replace the old data logging systems with new ones. He discussed this directly with the school principal. Also in the replacement of old data loggers, however, teacher F2 did not discuss this with her principal first. She checked all the details with fellow teachers before she decided where to ask for the funding required for the replacement exercise. It is therefore proposed that teachers would devise different ways to handle ICT related challenges encountered.
In the interviews, no teachers mentioned that they had insufficient resource materials for teaching and learning chemistry. This can be related to the rich set of resource materials provided by textbook publishers, and the fact that there is a lot of resource materials that can be downloaded from the web. For instance, teacher M1 said he would gather video clips like "The Element Song" from the web to enrich his presentation files, and teacher F1 cited video clips like "Braniac-Alkali metal + water = BANG!" and "diet coke + mentos" from YouTube as funny and she would use them to arouse students' interest in chemistry. Teachers F2 and M3 will request for the up-to-date resource materials from the web. Teacher M2 cited the following example as a very good instance of using ICT for accessing the latest information related to chemistry: the brutal acid attack when two bottles of corrosive liquid were dropped into the busy pedestrian zone. He argued that this is a very good opportunity to make use of ICT to enhance students' understanding about some factual chemistry and how science and society are related, and to facilitate students to deliberate on social values. Also, he could make use of the latest information from the web immediately after the incidents for teaching and learning purposes.

In short, teachers mentioned very little challenges about the use of ICT. Instead, they argued indirectly that ICT provided them with different opportunities for enhancing teaching and learning processes. Nevertheless, there is a need to review the current situation and find out if ICT is used in the ways many ICT in education experts like Chin (2007) have described.
5.6 Exemplary use of ICT in teaching and learning

Question 8: Please describe a case that you think is an exemplary use of ICT in teaching and learning chemistry.

This study is to gather information to reveal what teachers believe about the use of ICT for teaching and learning. Hence, what a teacher suggested as “exemplary use of ICT in teaching and learning” is likely to be a piece of evidence for inferring about the teacher’s subtle pedagogical orientation.

On figuring out the exemplary use of ICT, teacher F2 deliberated for quite a while and described the following scenario related to the use of data loggers.

A day before a student practical work session involving use of data loggers, I will inform my students, verbally and by posting a message on the intranet notice board, they have to study the online presentation on how to set up the experiment for data collection and how to operate the software. The online presentation shows step-by-step operation procedure, with descriptions and screenshots. In the practical work session, I will brief my students succinctly, check their understanding orally and then ask them to do the experiment. As observed, students can handle the hardware and software with ease, I think the online presentation help my students to complete the experiment more effectively and efficiently.

Teacher F2 added that the use of online presentation was not the only means to facilitate students to acquire the procedural knowledge or know-how. There were other means to achieve the same result. Nevertheless, she believed that the use of online presentation was a good one. Based on the descriptions, it is reasonable to say teacher F2 had a belief that an expository approach is an effective teaching and learning strategy.
Teacher F1, just like her partner F2, needed some time to figuring out the exemplary use of ICT. She described the following scenarios related to the use of animations and simulations in teaching and learning.

- In secondary 3 chemistry, I will use a number of animations to demonstrate how ionic bonds and covalent bonds are formed. The processes involved in bond formation are best presented by animations.

- In secondary 4 chemistry, I will use Model ChemLab (a simulation software published by the Model Science Software Inc.) to demonstrate how to do an acid-base titration, and at the same time how to plot a titration curve. With the simulation software, I can exercise a lot of control over the addition of titrant - drop by drop or rapidly, and other factors in a cyber world.

A post interview scrutiny of the website of the publisher (Model Science Software Inc., 2008) revealed that the Model ChemLab software can also simulate laboratory processes like decanting, pouring and heating with water baths, and experimenting virtually with a number of variables, e.g. temperature, weight, pH, conductivity, voltage and volume.

According to Hofstein and Lunetta (2004), normal laboratory activities and computer simulations play different roles in teaching and learning of science. They put forward the following remarks:

Whereas laboratory activities are designed to engage students directly with materials and phenomena, simulations can be designed to provide meaningful representations of inquiry experiences that are often not possible with real materials in many science topics. In such cases, simulations engage students in investigations that are too long or too slow, too dangerous, too expensive, or too time or material consuming to conduct in school laboratories.
With the comments by teacher F2 and the academics, it is possible to say simulations extend students' learning experiences, in particular, experiences that are not readily available through hands-on practical work in the school laboratory. In addition, simulations provide students with experiences which are often too difficult or impossible to obtained in real life. With reference to the descriptions, it is reasonable to say teacher F2 has a belief that teaching should go beyond the expository approaches, and the teacher prefers to have more student-centred approach in junior secondary level chemistry. With the limited pieces of information, it is possible to speculate that teacher F2 has an inclination to use a more constructivist oriented pedagogy.

Teacher M2 described his exemplar use of ICT firstly by describing his personal commitments outside his school. Firstly, he mentioned that he was involved in a number of public services like overseeing a science subject “Science & Technology” (CDC, 2003b) for secondary 4 to 5 students, and providing support to chemistry teachers in the advanced level chemistry TAS (HKEAA, 2008). Hence, he did not stay in his school for long hours. He then said he is dedicated and is willing to help his students to learn. Under the said situation, he asked his students to contact him by e-mails for help to solve problems. He quoted the following numbers of emails received for the researcher's reference.

<table>
<thead>
<tr>
<th>Period</th>
<th>Number of emails received from students per fortnight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non examination period</td>
<td>20-30</td>
</tr>
<tr>
<td>Before examinations</td>
<td>40-50</td>
</tr>
</tbody>
</table>

He added that in March and April each year, secondary 5 or 7 students, i.e. students going to take the public examinations (home study students), they would contact him frequently by e-mails to gather support. It is understandable that students going to public examinations would study at home and they could not meet their teachers face-to-face. Teacher M2 made use of CMC tools to maximize the interactions with his home study students. This is a
good piece of evidence that ICT can facilitate the communication of teachers and students, in an asynchronous mode with little physical constraints (Section 5.2c). The practice described is a possible means to solve the learning problems encountered by distance learners, there is no need to make use of face-to-face meetings.

There is one more point worth some discussion. Teacher M2 described that he often sent challenging chemistry related questions using emails to foster students' thinking skills through e-mail. For instance, teacher M2 put up a question, "What are the volatile organic compounds found in a newly refurbished apartment?" through the intranet e-mail system. All secondary 4, 5, 6 and 7 chemistry students were invited to response. This would be a technically non-challenging task for teacher M2 because of the easy access to email accounts of all the targeted students using the intranet system. Teacher M2's students were willing to undertake a search and then responded to the questions, and they could get some small souvenirs if they could answer correctly. Hence, it is possible to say teacher M2 is making good use of ICT for communication with students to enhance students' learning. ICT is used to reach students directly in virtual space and students are expected to participate more actively in the learning of chemistry.

With reference to the above descriptions, it is reasonable to say teacher M2 is using CMC tools to facilitate students' learning. His preferred pedagogy was not solely based on the expository approach. However, there was not sufficient data from the interview to judge whether teachers believe in a constructivist pedagogical orientation.

Teachers M1 and M3 deliberated for a lengthy period of time on their own exemplar practices in using ICT for teaching and learning, but still they could not present any special exemplar scenarios to the researcher. Given the limitation of the time available for the interview, it is
not possible to gather useful information related to the issue being discussed by teachers M1 and M3. It is thus a wonder why teachers cannot suggest exemplar ICT based lessons or learning scenarios. One of the explanations is that ICT becomes an ordinary item in teachers’ toolboxes; ICT is already part of their teaching routine. Furthermore, teachers accommodate ICT fully into their current teaching and learning processes (Dwyer, Ringstaff & Sandholtz, 1990). In other words, ICT is being used in ways that fit teachers’ pedagogical routine, but not necessarily innovative student-centred self-learning or interactive learning (Chin, 2007).

5.7 Summary

As mentioned in the early part of this chapter, a purposeful sampling strategy was adopted so as to find interviewees with maximum variation. Two female teachers and three male teachers participated in this part of the study. It is noted in most cases, there was no difference in gender responses except that a female teacher reported that the tools for drawing molecular structures were difficult to use while two male teachers suggested otherwise.

On perceived usefulness of ICT-based tools, all teachers found the tools listed in the survey questionnaire useful. In particular, they agreed that “presentation” and “animation” were very useful and somewhat useful respectively. In addition, teachers interviewed also suggested that computer-mediated communication tools were useful and the tools can facilitate home study students to learn. On the contrary, teachers found IWB a bit unfamiliar and they needed some time to explore the potential of IWBs in teaching and learning.

On ease of use, it was found that teachers are quite comfortable with the use of ICT and their students are ready to learning with ICT. No major challenges were reported. More precisely, all teachers agreed that ICT-based tools were easy to use, and there were no
significant barriers or hindrance to their use of ICT for teaching and learning in the schools. In addition, teachers mentioned that office automation tools were particularly easy to use and useful. Nevertheless, all the teachers mentioned very briefly about the use of constructivist oriented tools like "Knowledge Forum" or "ChemSense" with their students. This is an indication that teachers still have greater confidence in teacher-centered instruction, but less confidence in student-centered learning, as an effective pedagogy. Students are considered as "tabula rasa". To realize the full potential of ICT, students should be encouraged to self-learn, and participate in interactive learning (Chin, 2007) or student collaborative research (Kozma, 2003).

Nearly all the teachers interviewed said they always or very frequently use Powerpoint presentation with embedded video clips for lesson delivery. A teacher reported that he used Powerpoint presentations so that he did not need to write on a blackboard. In addition, some teachers suggested that a LCD projector is the most important piece of ICT related hardware for teaching and learning. Hence, it is argued that the use of transmissionist oriented approaches is still common practice. This is somewhat consistent with the findings reported by BECTA (2007) and Kozma (2003). Though this study had not attempted to gather evidences about whether teachers are using interactive learning strategies by direct classroom observation, it is however reasonable to speculate that all the teachers interviewed were using the one-to-many instruction mode (Chin, 2007) extensively, and with limited interaction.

As mentioned previously, it is definitely true that both young and experienced teachers have quite different exposure to various applications of ICT during their school years. The jargons "digital natives" and "digital immigrants" have been used repeatedly in this part of the thesis. With teachers’ diverse experiences with ICT, it is reasonable to put forward the argument that
different training courses with different foci should be provided to teachers with different experiences with ICT. In order to attain goal C suggested by Prestridge (2009), that is, to transform the existing pedagogy, experienced and young teachers should be provided with differentiated training courses.

To conclude this chapter, all the interviewed chemistry teachers perceived ICT as useful and easy to use. They are using ICT for teaching, and adopt the "transmissionist orientation" (Gobbo & Girardi, 2001) as the dominant pedagogy in their classrooms. Nonetheless, according to Chin (2007), the potential of ICT can only be realized by using an approach that is student-centered, not technology-centered. In other words, the best approach must be one that can cater for the individual learning needs of students, not merely for the convenience of teaching. Hence, the provision of sufficient support, in terms of subject specific hardware and software as well as pedagogically sound ICT-based learning resources (APEC, 2004), to teachers is an important means to remove first order barriers (Ertmer, 1999). After that, there is a need to provide teachers with training opportunities on how to adopt constructivist oriented pedagogy in classrooms, and reflection sessions that facilitate teachers to reflect on the shortcomings of their current practices. There is a need for different support measures for teachers to address the second order barriers (Ertmer, 1999). What teacher M2 mentioned in the interview is a good support to what Ertmer just argued:

To use IT for teaching in my school is not problematic at all. We have easy access to computer, different kinds of servers (like video servers, web servers, file servers, etc.). In addition, we have an IT technician in school, and students being trained as "IT prefects" to provide IT support for teachers. Nevertheless, some teachers are still tried to stay away from the regular use of IT for teaching. I guess they are very confident with their usual teaching methods.
6. Discussion and Recommendations

6.1 Introduction

This part of the thesis attempts to put all the observations and interpretations of this study together in a succinct way. In this connection, the key findings related to and the factors that affect Hong Kong chemistry teacher's beliefs and practices will be discussed here.

Given the fact that a number of issues like hardware provision (access and connectivity), basic professional development in the use of ICT (teacher enablement), and students' readiness to learn with ICT are resolved, there are some deep and tacit factors shaping teachers' practices of using ICT tools in their classrooms. Based on the findings in this study, the most important tacit factors will be depicted below. After that, the recommendations on how to facilitate Hong Kong chemistry teachers to use ICT for teaching and learning in the appropriate ways will be presented. Lastly, the limitations of this study as well as the directions for future research will also be presented.

6.2 Key findings and discussion

a. The use of ICT-based tools for teaching and learning of chemistry in Hong Kong

The purpose of this study is to examine how Hong Kong chemistry teachers use different ICT-based tools in teaching and learning. With the questionnaire used, it is possible to find out what types of tools teachers were using, and how frequently the tools were being used.

Based on the descriptive statistics of the quantitative data (Section 4.6), teachers participated in this study used office automation tools very frequently, and then didactic oriented tools and process oriented tools. In more concrete words, for the teachers who participated in this study, they did use presentation software more frequently than animation, and in turn more frequently than simulation and Webquest (Dodge, 2001) in their classrooms. This is a piece of evidence that teachers have a transmissionist oriented
teaching style (Table 2.2). This finding is very similar to that from the study on high school chemistry instructional practices by Tai and Sadler (2007), "most common was lecture with 90.6% of students selecting the choice '2–3 Times per week' or 'Everyday'". From the mean ICT_usage score, teachers did use ICT for teaching and learning. Nevertheless, there were no teachers with an ICT_usage score in the highest range 56-70 (Figure 4.2). This suggested that ICT-based tools are not being used very frequently and they are not the most dominant pedagogy among teachers in this study.

To explain why teachers are not using ICT extensively, it is speculated that accountability for students' attainment in high-stake public examinations has a significant impact on teachers' decisions on the use of ICT-based tools for teaching and learning. This speculation is in line with the findings of a recent survey of teachers' use of ICT (EMB, 2005). The report suggested that teachers say, "the pressures of the public examination-driven system were another common reason for not incorporating IT into their teaching" (Section 2.11).

To understand the situation, a brief introduction to the local public examinations arrangements is needed here. Locally, there are two major public examinations, namely, the Hong Kong Certificate of Education Examination (HKCEE) held at the end of the fifth year of secondary schooling, and the Hong Kong Advanced Level Examination (HKALE) held at the end of the seventh year of secondary schooling. The two examinations are high-stake in nature: they adopt norm-referenced scores interpretation (Stiggins, 2006) and they are used for selection purposes. Many stakeholders, including school supervisors, principals and parents, will make use of the above examination results for accountability purposes. Teachers are therefore quite conscious about and would consider which pedagogy could be used to enhance their students' attainment in the public examinations.
After 2003, the former Education Department of the local government introduced the Hong Kong Schools Value Added Information (HKSVAI) System. The system makes use of the performances of students in their first year of secondary schooling (i.e. measured by the Academic Ability Index, or AAI) and students in the fifth/seventh year of secondary schooling (i.e. HKCEE and HKALE results), for the generation of “School Value-added Measures” (SVAM) for individual subjects and for specific subject groups (HKSVAI, 2007). More than often, the SVAMs are also being used for accountability purposes in different schools.

To be accountable to various stakeholders, student attainments in the public examinations and the SVAMs will place some pressure on classroom teachers, including chemistry teachers. It is likely that some teachers will be “teaching to examinations only”. Teachers have to make tough decisions on selecting the most effective and efficient means to raise students’ attainments. Many teachers will likely model their teaching on the style that makes their students most successful in public examinations - teacher-centered didactic forms of teaching, or a teaching style with a transmissionist orientation (Table 2.2). The said teaching style will then be implemented in classrooms. In short, there is no doubt that teachers will resort to the use of the pedagogy they believe to be useful. As a result, teachers will pick a few ICT-based tools that match their pedagogical beliefs and include them in their personal repertoires. This can be a reason why teachers enjoy the use of multimedia enhanced presentation. Using the jargon in this study, a high frequency index will be expected. Alternative teaching and learning practices with a constructivist orientation will most likely be ignored.

It is argued here that accountability per se is not a problem, but if the accountability relies heavily on the public examinations results, one way or another, they will be an impact on
teaching and learning. This impact will be particularly prominent when teachers are completely free to adopt pedagogies for raising students’ attainment. Even if it is a mandatory for teachers to adopt a constructivist approach to teaching and learning, however, they are not provided with concrete evidence that the new paradigm can help students become success in public examinations or increase the SVAMs. Consequently, ICT may not be used in the most appropriate ways. The scenario is getting even worse if the public examinations do not place sufficient emphasis on the assessment of generic skills like communication, reasoning and problem solving (CDC, 2002). Various ICT-based tools that address the said generic skills are likely to be ignored entirely. To align teachers’ pedagogical practices with the new paradigm, some modifications to the HKSVAI System have to be made. For instance, some evaluation criteria indicating the use of the new paradigm at the classroom level have to be included.

b. Perceived Usefulness and Perceived Ease of Use of ICT-based Tools

With descriptive statistical data, it is found that teachers in this study had positive to very positive beliefs about the PU of ICT-based tools, or the PU had a marked lop-sided distribution (Figure 4.4). The same is true for the PEoU, or the PEoU had a marked lop-sided distribution (Figure 4.5). In addition, with some inferential statistical techniques, a statistically significant gender difference in PU was found; and male teachers had significantly more positive beliefs about PU of ICT-based tools ($t=-4.127, p=.000$) than female teachers. With the application of the same data analysis technique, a statistically significant gender difference in PEoU was also found ($t=-3.055, p=.003$). In essence, it was sound to say that teachers have positive beliefs about the usefulness and ease of use of the ICT-based tools, and this is particularly obvious among male teachers.
Morris and Venkatesh (2000) and Venkatesh et al. (2003) argued that gender is a confounding variable in their research about technology adoption. In an international study on the use of computer in education, Reinen and Plomp (1993) found that male teachers in secondary education had more self-confidence in relation to computers than did female teachers. A recent study on the difference in actual and perceived online skills suggested that men and women do not differ greatly in their actual online abilities but women perceived themselves as having weaker online abilities than men (Hargittai & Shafer, 2006). This study also revealed the male and female chemistry teachers have statistically significant differences in beliefs about ICT, that is, PU and PEoU (Sections 4.7 and 4.8); as well as different views towards the tools for drawing molecular structures (Section 5.3a). The different beliefs about the use of ICT may be related to tacit psychosocial shaping processes in which different activities evoke dissimilar reactions from the social and cultural environment (Lent, Brown & Hackett, 1994). Quite commonly working women have more family commitments after work than men; and often play mostly passive and stereotypical roles, and are not active computer users (Volman & van Eck, 2001). In essence, there are some robust and relentless social and cultural perceptions of male and female abilities and preferences (Tang, 2003).

Hargittai and Shafer (2006) further remarked that less positive perceptions about online abilities would affect women's online behaviour. The remark was in line with some theories or models like TRA, TPB and TAM. If this is the case and the phenomenon can be extended to a more general scenario like the use of ICT for education, it is needed for policy makers, teacher trainers or innovation promoters to be aware of female teachers' perceptions. With a view to promote the use of ICT in teaching and learning, it is necessary to put in more effort to raise women's perceptions of their own ICT abilities, which will in turn help promote the use of ICT at the classroom level.
c. ICT usage and student abilities

With some inferential statistical techniques, it is revealed that ICT_usage score varies with the variable student ability (F=4.146, p=.018). Teachers with students of high ability reported that they used ICT more frequently than their colleagues with students of low ability students. It is speculated that teachers consider whether their students can learn best from textbooks or with ICT. Teachers may consider the use of ICT for teaching and learning even more challenging than using textbooks for struggling students. Hence, the struggling students will unlikely be asked to use ICT to handle additional information presented in multimedia (like graphics, text, animations, videos etc.) or to create their own products with ICT-based tools (Kozma, 2003) in order to demonstrate their achievements.

d. ICT usage and teachers' ICT competency levels

It was found that teachers with higher ICT competency levels used ICT more frequently than their colleagues with lower ICT competency levels (i.e. AIT > UINT > IIT > BIT), and a statistically significant difference was found for ICT_usage scores among teachers (F=3.577, p=.016). Teachers with higher ICT competency had statistically significant higher PU, but not PEoU, than teachers with lower ICT competency (F=2.832, p=.000). To interpret the findings, it is known that teachers with high ICT competency levels had received very intense tools-based training in their early career pathway in ICT in education (ED, 1998), as well as gained a great deal of hands-on experience with the use of computers in education in their schools. In addition, they are the "role models" for the ICT in education in various subjects. In short, these sub-groups of subjects are cognitively very well aware of different applications of ICT (Straub, 2009) and hence they should be able to pick up the most useful ICT tools, and they would unlikely be hindered by technical reasons. It is argued here that they will have positive perceptions about the usefulness and ease of use of the ICT-based tools.
e. Will the use of ICT for teaching and learning gain momentum with time?

The "slow revolution" explanation refers to an idea that small changes accumulating over time do create a transformation, and the process must be slow (David, 1990; cited in Cuban, Kirkpartrick & Peck, 2001). Using the examples of the use of electricity and steam engine, the two technologies took several tens of years to complete the revolution from their inventions to commercial applications in society. Hence, the slow revolution explanation seems to be reasonably plausible. Following the same school of thought, some people may argue the use of ICT for teaching and learning is analogous to other technology adoption: it takes time. Hence, one may argue that a slow uptake of the use of ICT in teaching and learning is not problematic.

Nevertheless, from the history of the use of the motion picture and the radio for education (Chapter 1), the "slow revolution" explanation is not necessarily a good explanation for why ICT-based tools are not widely adopted by local teachers. As mentioned in Chapter 2, each local secondary school attained the following standard in terms of access and connectivity.

<table>
<thead>
<tr>
<th>Source of information</th>
<th>Access &amp; Connectivity</th>
<th>Number of desktop computers</th>
<th>Number of notebook computers</th>
<th>Student-computer Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMB, 2005</td>
<td></td>
<td>164.7</td>
<td>72.3</td>
<td>4.6</td>
</tr>
<tr>
<td>ED, 2001</td>
<td></td>
<td>135.6</td>
<td>33.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The revolution is complete if measured in terms of access and connectivity. Secondly, teachers and students are provided with a range of free digital resources, or access to numerous ICT-based tools for teaching and learning. Perhaps the most important of all, teachers and students have the basic competencies for using ICT for most purposes. Given the provision of hardware, digital resources available and users' ICT competencies, the "slow revolution" explanation is a bit distant from being a sound one for explaining why teachers are using only a small range of ICT-based tools for teaching and learning. To take the discussion a bit further, if the "slow revolution" explanation is reasonably valid, with more than 10 years
since the inception of the innovation, all teachers should now be using a few ICT-based tools extensively or a wide range of tools. Also, more experienced teachers should be using more ICT than the new comers. However, the said phenomenon cannot be found from the information gathered from the survey and by the interviews with teachers. Some intervention measures have to be implemented to promote the use of ICT for teaching and learning, and the reliance on the idea of the "slow revolution" is not adequate for the implementation of ICT in teaching and learning.

f. Conflicts of Beliefs
As revealed from the information gathered by the interviews and the survey, teachers are using only a small range of ICT-based tools for teaching and learning. Among all the tools, it is found that the most commonly adopted one is the use multimedia enhanced presentation in classrooms. Teachers enjoy using presentation files in conjunction with digital video clips provided by textbook publishers in their lessons. The frequencies of use of other ICT-based tools are in general low, in particular those with a constructivist orientation. In Cuban's words, the use of teacher-centered forms of instruction (Cuban, Kirkpatrick & Peck, 2001) is a prevalent and stable phenomenon. With the limited data gathered, teachers, at least some or may be many, are using new ways to do old things. It is reasonable to say there is some evidence to support the argument: "Many teachers are using ICT-based tools, paradoxically, to sustain traditional teaching and learning practices" (Cuban, et al., 2001).

ICT in education is often perceived as a catalyst for changes: change in teaching style, change in learning approaches, and change in access to information (Watson, 2001). In addition, ICT can be used to enhance students' abilities such as reasoning, problem solving, using multiple representations, communication, and making connections (Deubel, 2008).
These abilities will be useful for students in the future, i.e. in further study and working in an information based society (APEC, 2004). All the said goals or changes will call for the use of a new teaching and learning paradigm. As an example, it will be, however, less than satisfactory to learn that teachers make use of the latest Web 2.0 technology (White, 2005), a powerful collaborative read and write tool (Richardson, 2009), as a one-way communication tool.

The remarks on the use of technology in education made by Dwyer, Ringstaff and Sandholtz (1990) based on the ACOT project are still a very good reference for this study.

ACOT teachers are committed to educational change, yet they maintain conventional beliefs about schooling based on life experiences within the traditional system. Consequently, ACOT teachers go through intense inner conflict as they explore alternative approaches that sharply contrast their beliefs about teaching and learning.

The existence of intense inner conflict in using the ICT-based alternative approach and the traditional teaching and learning approach can be a good reason why local chemistry teachers made use of multimedia enhanced presentation as the most dominant classroom practice. The conflict is known to be difficult to resolve, if not impossible. Sustained effort with strong leadership (EDB, 2008), plenty of success stories and different implementation models (Foley & Ojeda, 2008), appropriate technical support and personal commitment etc. will be required.

To revolutionize teaching and learning practices, especially on the use of ICT for enhancing student abilities mentioned above, it does require the injection of a significant amount of resources, especially time for exploration, planning and testing new paradigms. Can teachers continuously afford the high personal price to get acquainted with, master, and
finally sustained the use of ICT for teaching and learning for a lengthy period of time? Will the dedicated teachers have to walk away as a result of exhaustion (Cuban, et al. 2001)? In order to facilitate teachers getting out of the aforementioned barriers to the use of ICT for teaching and learning, it is important at this moment to find ways to support teachers: allocating less non teaching and learning related tasks.

6.3 Recommendations
The recommendations presented here focused mainly on pedagogical approaches to be used and professional development related strategies for enhancing the use of ICT in classrooms.

a. New pedagogical approaches
According to Waller (2007), teachers in the age of information and worldwide communication are expected to use ICT in their teaching and learning. Creighton (2003, cited in Waller, 2007) also argued that teachers must transform their pedagogy to a constructivist approach that improves student learning. In short, teachers are expected to make use of ICT with a constructivist learning approach so that students benefit fully from their schooling. As revealed from the survey instrument, however, teachers are not making frequent use of ICT-based tools such as e-Group, ChemSense and Knowledge Forum (Figure 4.3) in conjunction with appropriate content in the curriculum. Together with the information gathered from interviews, teachers have rather strong inclinations towards the use of the transmissionist approach in their practices. Teacher beliefs about the transmissionist approach are reinforced by the resources provided by textbook publishers, as well as the accountability practices. Some measures will be required to bridge the gap in order to promote the change, either as an evolution or a transformation, towards the use of the constructivist approach. It will be doubtful whether students will be well prepared for the 21st century while being taught by a transmissionist approach. Teachers, should
therefore, be guided to make the change required or at least to reflect on their beliefs about
the pedagogical approach that suits their students. More encouragement or success stories
can be provided.

As a recommendation, it is possible to consider the use of "Calibrated Peer Review" (CPR,
2001) which is a web-based project that presents students with quality writings and
randomly and anonymously assign student assignments to their peers for review. It is
expected that students will be learning curriculum linked content in a constructivist manner
with the help of CPR. A long list of chemistry related topics is available in the assignment
library (CPR, 2001), for instance, the following topics are relevant to the local curriculum:

- Three Major Chemical Bonds
- Titration and Standardization: Basic Concepts
- Understanding the Equilibrium Constant "K"

Another teaching and learning strategy is the "Webquest" (Dodge, 2001). According to the
information listed in the website, a "Webquest" is an inquiry-oriented lesson with a definite
format. A small group of students is organized to work together to solicit information from
a few designated websites and then produce a report. Just like calibrated peer review,
teachers can assign curriculum linked topics for their students, and students will be learning
in a constructivist manner with the help of ICT. Current science and technology issues like
the use polyacrylamide gel (PAAG) and melamine tainted milk are very good topics for doing
Webquests.

b. Professional development of in-service teachers

Talking about the period around the 1990s, most of the teachers had limited ICT skills and
hence, the training they needed would be skill based courses. At that time, teachers would
enjoy formal courses on the use of some basic ICT-based tools like how to use office
automation tools. However, it is no longer the case now. As revealed from the interviews,
all teachers were confident in using office automation tools, and they already possessed skills quite beyond the basic. It is obvious that they would have new training needs. Based on the results of this study, not many teachers are using constructivist approaches in their teaching. If someone put up a question: "Are teachers well prepared for using ICT for teaching and learning using constructivist approaches?", the answer is pretty like "Not yet".

For in-service teachers, they will also need more professional development opportunities that address both the ICT skills required and the appropriate pedagogical approaches that can be used. Furthermore, teachers will also be provided with time to experiment with different pedagogical approaches (Gifford, 2004, p. 165) and support needed so that they can attempt different ICT practices (Waller, 2007, p.122). The remark suggested by Steve Olson on chemistry teachers' training need is also a good reference here.

Most high school chemistry teachers have taken college courses above the level they are assigned to teach, but they report needing help using technology (ICT) in science instruction, teaching classes with special needs students, and using inquiry oriented teaching methods (Olson, 2009).

Gifford (2004) reported the suggestions of NCREL (2000) on how to organize professional development programmes for in-service teachers:

- sustain over long periods of time
- provide hands-on experiences
- relevant to teachers' content areas
- connect with student learning
- support teachers' efforts to experiment with ICT

In addition, the ACOT study also put forward the following remarks on how professional development programmes can be conducted. The suggestions are closely in line with those put forward by NCREL, but more on the use of a constructivist approach:
To facilitate teachers' development of beliefs about technology's ability to enhance teaching and learning and adoption of technology, programmes offered must include enough time for teachers to become comfortable using curriculum specific software applications and integrating it into content specific, project-based activities. More intense instruction and follow-up support should be provided on how to integrate technology into individual specific areas. Training should focus on more sophisticated uses of technology within constructivist environments, which foster development of students' critical thinking and problem-solving skills. Further, teachers must have access to on-site support, both pedagogical and technical. (Cited in Gifford, 2004, p.165)

According to Glatthorn (2005), teachers develop professionally when they realize increased experience and examine their teaching systematically (p.41). Finally, the key concept on professional development, the approaches and related models proposed by the local government appointed Joint Consultation Service Team (2007, p.54-55) should be considered in greater details:

... professional development can be conceived as a vehicle to facilitate teacher to become a reflective practitioner who constantly engages him/herself in improving or reconceptualising their own practices.

Moreover, the team also suggested three different approaches and related models that can be used. Details of the approaches are listed in Table 6.1.

Table 6.1 Approaches and Models for Teacher Professional Development

<table>
<thead>
<tr>
<th>Suggested Approach</th>
<th>Models for Teacher Professional Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>System-wide Approach (SWA)</td>
<td>Cascade Model, FAN Model, and the Train-the-Trainer Model</td>
</tr>
<tr>
<td>School-based Approach (SBA)</td>
<td>Mentor-Mentee Model and the Teacher Leadership Model</td>
</tr>
<tr>
<td>School-clustering Approach (SCA)</td>
<td>With the models used in SBA, but more emphases on sharing and collaboration among schools.</td>
</tr>
</tbody>
</table>
In short, Hong Kong chemistry teachers still require a lot of training opportunities on how to use ICT for teaching at the classroom level.

c. Training of pre-service teachers

For pre-service teachers in this era, they should be able to master most of the basic ICT skills. For instance, they should have no problem in using office automation tools (though the spreadsheet tool is not necessarily the case). Nevertheless, are they really well prepared for using ICT for teaching and learning? The answer is probably "Not yet". From the interview data gathered from the two young teachers, there are also some evidences to support the above argument. In this connection, initial teacher preparation programmes offered by the local teacher preparation institutes should include more model ICT use for teaching and learning, as well ideas on how to integrate ICT in the curriculum. The use of Knowledge Forum (KF, 2009) and Webquest (CUHK, 2007) are good examples of ICT-based tools for teaching and learning. Gifford (2004, p.165) reported the suggestions of ISTE (2003) which summarize this part of the discussion.

Leaders of the teaching profession as a whole must address the problem of ill preparedness of new teacher to use technology systematically and strive to transform teacher preparation programmes to include technology integration strategies.

All in all, it is speculated that a coherent set of strategies including provision of ample time for exploration of the use of ICT, planning and testing new pedagogical approaches with ICT, sound ICT facilities, ample digital resources in line with the new paradigms (EDB, 2008), access to sufficient and in-time technical support, changes in the accountability systems etc. will be needed.
6.4 Limitations of this study

As mentioned in Section 3.6, there are some limitations of this study and most of them have already been dealt with. However, after some reflection, it is known that there were a number of limitations related to the subjects participating in this study. Firstly, only chemistry teachers in Hong Kong were included in this study. Other subject teachers like biology, physics, geography, languages, etc. are very likely to be different from the subjects in this study. Also, it is will hard to predict whether the findings on Hong Kong chemistry teachers from this study will be applicable to chemistry teachers working in other countries. If possible, the study will be more meaningful if it can be extended to include chemistry teachers working in nearby cities such as Macau, Guangzhou, Taipei, Kuala Lumpur, Singapore, etc. Hence, it is imperative to point out this limitation in the first place. As discussed in Section 4.2, the number of questionnaires returned was around 120. The response rate for mailed questionnaires was a bit low (Babbie, 2004). Given the resources available in this study, it is hard to overcome the said limitation by boosting the return rate. It was further deliberated on whether an incentive such as a lucky draw of a personal computer (Waller, 2007, p.190) should be used to increase the return rate so that more questionnaires can be collected. It was believed that the practice would attract respondents to return the questionnaire just for the sake of lucky draw. Consequently, the data obtained might have low validity. This could create a serious threat to the validity of the data collected, hence, there was no further action to boost the response rate.

For this study, a cross-sectional analysis (Trochim & Donnelly, 2006) is being used. Hence, it is reasonable to pose the question is the time of this study the beginning of ICT adoption (Rogers, 2003) or its final stage? A longitudinal study, either cohort study or trend study, on the same themes should be useful to address the aforesaid query (Cohen, et al., 2000, p.174).
From the quantitative data obtained from the questionnaires and the document analyses, factors like equipment, support or training are not problematic to active ICT users in local secondary schools. However, from a further literature survey on the latest developments on TAM (Venkatash, et al., 2003; Ndubisi, 2006; Almutairi, 2009), it is known that there are many factors like gender, age, experience, and voluntary use of ICT could affect teachers’ use of ICT-based tools in teaching and learning. It is not possible to address all these factors in this study because of resource constraints.

In the qualitative part of this study, a purposeful sampling strategy was used: one experienced male teacher interviewed for piloting purpose; one experienced male and one experienced female, one young male and one young female teacher were interviewed. The total number of subjects participating in this part of the study was five. It is argued that more teachers from different schools and having different personal attributes could have been interviewed. It is expected that more information could have been gathered to make the study more comprehensive. As an example, teachers from schools with students of moderate to low abilities would likely provide a set of data in addition to that already gathered.

It is clear that this study focused on the teacher’s perspective and attempted to gather information about their use of ICT for teaching and learning. More specifically, teachers’ beliefs about ICT, their ICT skills, and the availability of resources were addressed. However, only a limited amount of resources were allocated to gather information related to whole school characteristics like school culture and ethos, school vision and leadership which are considered to be important for “success” in the implementation of ICT (Penni, 2003). Thus, it is possible to extend the qualitative part of this study to scrutinize how whole school characteristics and other teachers’ attributes interact to create an encouraging environment for the use of ICT in teaching and learning.
6.5 Directions for future research

At the end of this thesis, it is time to outline some possible directions for future research. It will be interesting to extend this study to four areas so that some aspects already examined in this study can be understood more deeply, and to extend our understanding of the applications of some other ICT-based tools that are not included in this study.

a. Unified Theory of Acceptance and Use of Technology (UTAUT)

Unified Theory of Acceptance and Use of Technology (UTAUT) formulated by Venkatesh, et al. (2003) is an extension of the technology acceptance model or TAM (Section 2.8). The UTAUT aims to further scrutinize behavioural intention and subsequent usage behaviour. According to Venkatesh, et al. (2003), the UTAUT was developed through a review and consolidation of the constructs of eight models that earlier researches had employed to explain information systems usage behavior. The eight models are theory of reasoned action (Section 2.5), TAM, motivational model, theory of planned behavior (Section 2.6), a combined theory of planned behavior / technology acceptance model, model of personal computer utilization, innovation diffusion theory, and social cognitive theory. Subsequent validation of UTAUT in a longitudinal study found it can account for 70% of the variance in behavioural intention (Venkatesh, et al., 2003). Hence, the UTAUT is regarded as a good theory for a study on the use of ICT.

The UTAUT put forward the idea that there are four key constructs, namely performance expectancy, effort expectancy, social influence, and facilitating conditions, which are direct determinants of behavioural intention and behaviour. In addition, there are also four mediating variables, namely gender, age, experience, and voluntariness of use, that impact on the four key constructs on behavioural intention and behaviour. The UTAUT is summarized in Figure 6.1.
The theoretical framework for this study covers performance expectancy (PU), effort expectancy (PEoU) and facilitating conditions (CONTX). The study found that gender was a factor that mediated ICT usage. However, age and teaching experience were not factors that mediated ICT usage. It is suggested that this study can be extended to include variables like social influence, voluntariness of use in the future. The inclusion of these variables will make a study of the use ICT more comprehensive.

b. Web-based course platform

Recently, a number of tertiary education institutions like the local Open University invested quite a great deal of resources on the development of web-based courses platform: Online Learning Environment or OLE (OUHK, 2009). In addition, there are also similar development projects for secondary schools (eClass, 2009; HKEdCity, 2005; OLTA, 2010). Wong and Li (2006) reported that web-based courses are important ICT-based tools.
In general, it was found that most of the commonly used ICT tools (i.e. Internet, Presentation software, Communication software, Simulation software and Drill-and-practice software) exert no effect on the mean score for changes in learning, except the web-based course platform and software for constructing knowledge. Specifically, teachers who indicated the web-based course platform and software for constructing knowledge as the most commonly used ICT tools had a little higher mean score of changes in learning than those of their counterparts.

Furthermore, the ICT-based tool is becoming more and more popular as there are at least two open source development projects, namely Moodle and Sakai. Together with the fact that the cost for a reasonably powerful server machine is affordable, and students are competent ICT users, school teachers should have only a low level of challenge to make use of the products from the two development projects to enhance teaching and learning.

This study, however, did not include the tool during the development phase. Hence, it is suggested that any future study on the use of ICT for teaching and learning should examine the said tool alongside others.
c. Web 2.0 and Edblog

As mentioned in part b above, this study has already included a number of ICT-based tools for teaching and learning. However, it is duly recognized that all the ICT-based tools included in this study (Appendix C) were not exhaustive. Among all the latest applications of ICT in education, perhaps Web 2.0 is the most significant. According to White (2005), Web 2.0 refers to a loose collection of recently developed concepts and technologies including Weblogs, Wikis, podcasts, Web feeds and other forms of publishing. Technically speaking, Web 2.0 also includes social software, Web APIs, Web standards, online Web services, AJAX, and more. Among all the tools linked to Web 2.0, blog or edblog (Richardson, 2009) is a rather common tool that has not been included in this study.

As defined in Wikipedia (2009), a blog (a contraction of the term ‘Web log’) is a web site, usually maintained by an individual with regular entries of commentary, descriptions of events, or other material such as graphics or video ... with regular entries are commonly displayed in reverse-chronological order. Technorati (2008), an Internet search engine, put forward the following argument on the importance of blog nowadays.

The power of weblogs is that they allow millions of people to easily publish their ideas, and millions more to comment on them. Blogs are a fluid, dynamic medium, more akin to a “conversation” than to a library — which is how the Web has often been described in the past.

Will Richardson, a notable edublogger, put forward arguments for and suggests educators to reflect on the use blog in education (or edblog):

... tens of thousands of teachers and students have begun using some of these tools (including blogs and wikis), but the vast majority of educators still have little or no context for these shifts ... very few people, educators or otherwise, have yet to experience the transformative potential of these new tools in terms of their own
personal learning ... rethink the way we communicate with our constituents, the way we deliver our curriculum, and the expectations we have of our students (Richardson, 2009).

In many domains like politics, journalism and business, blogs are all-pervasive. However, the use of edblog is very limited, just as is often the case, education has been slow to adapt (Richardson, 2009).

Dalsgaard (2009) described, "a weblog (and possibly edblog) in itself is not a social or collaborative tool, but is rather individual and also often personal ... and a weblog can function as that individual's representation on the web. However, this representation can form the basis of socialization on the web ... When a weblog is related to other weblogs, the weblogs become social, and communities or networks are formed". Based on this piece of information, an edblog can be used as a tool to support the use of constructivist oriented, collaborative learning.

With all the information presented above, it is still not possible to state with confidence whether the use of an edblog can enhance the quality of education. As argued in Chapter 1 on the use of the motion picture or the radio in education, will edblog become just another "education gismo" that will have a shallow or non-sustainable impact on teaching and learning. A detailed study on the use of Web 2.0 technology or edblog will be a worthwhile study. Hence, it is suggested here that this study can be extended to examine the abovementioned ICT-based tools.
d. Mobile Learning and Cloud Computing

In the last couple of years, there has been an impressive uplifting change in the traditional desktop and laptop computers, as evaluated in terms of computing power, storage, price, accessibility, etc. At least for literally all local students have easy access to computers and the Internet for learning. In addition, the availability of mobile devices such as ultra-mobile PCs (UMPC), elegant smart phones, personal digital assistants (PDAs), iPods, MP3 players (Najmi & Lee, 2009), and the state-of-the-art e-book readers like Amazon kindle and Apple iPad, would creating mobile learning (or m-learning) opportunities. Locally, there is at least one m-learning pilot project being carried out in a secondary school (Pui Ching Mobile Learning Project, 2009)

M-learning lends itself to learning at any time and at any place (Corbeil & Valdes-Corbeil, 2007) or meets the “just enough, just in time, and just for me” demands of twenty-first century learners (Peters, 2009). It is, however, recognized that the use of m-learning is not without barriers. Not only are there technical issues to be resolved, but research informed and pragmatically viable pedagogical practices need to be developed. In other words, teachers should be provided the hardware required, technical support for networking, m-learning resource materials, as well as sound pedagogical advices. In this connection, it is suggested this study can be extended to areas like what are chemistry teachers’ beliefs about the role of m-learning, how to integrate m-learning with laboratory based pedagogies, or what are the most appropriate pedagogical approaches for m-learning in order to combat students’ alternative conceptions (Garnett, Garnett & Hackling, 1994). Connecting students to e-learning resources (EDB, 2009b) using different mobile devices to facilitate some meaningful learning activities will also be an interesting area to exploit.
The term "cloud computing" refers to a number of web based computing services delivered through the Internet. Typically, three different services are provided.

1. **Software as a Service (SaaS)** – delivering online applications to clients (e.g. Google Doc);
2. **Hardware as a Service (HaaS)** - delivering processing power, storage and data transfer to clients (e.g. Amazon Elastic Compute Cloud); and
3. **Platform as a Service (PaaS)** – delivering different virtual computing platform for application development.

With the services like SaaS and HaaS, school teachers and students can make use of low computing power hardware (in particular mobile devices) to do a number of computing power intense learning tasks. Though the cloud computing appears to be a bit unfamiliar to the general public, it is believed that in the near future, the valuable learning opportunity offered by the combination of cloud computing and mobile devices will be available. Hence, it is suggested that this study can also be extended to the said combination.
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• Newhouse, P., Trinidad, s., & Clarkson, B. (2002). Teacher Professional ICT Attributes


List of Appendices

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B. Consent letter for participation in the Questionnaire Survey A3
C. Survey questionnaire A4
D. Consent letter for participation in the interview A10
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H. General guidelines for assessing qualifications of science permitted teachers (ED, 1990) A15
Appendix A

Four Levels of IT Competency for Hong Kong SAR Teachers

1. Basic level: Awareness of the need to take up the new role as a learning facilitator, general computer operation and basic skills such as word processing, surfing through the Internet as well as operating readily available educational software. About 18 training hours may be required.

2. Intermediate level: Capability to use IT tools and make use of teaching resources available on the Internet and Intranet etc. in classroom teaching and lesson preparation. About 30 training hours may be required.

3. Upper intermediate level: Capability to handle computer networking, resolve simple hardware and software problems, making more advanced use of Authorware for lesson preparation etc., and understanding the characteristics and uses of different IT tools and resources. 30 training hours in addition to those of intermediate level may be required.

4. Advanced level: Capability to understand the functions of computer managed instruction systems, evaluate the effectiveness of instructional computer programs, design instructional materials with use of IT, and choose appropriate IT equipment to meet a school's needs. 120 training hours in addition to those of upper intermediate level may be required.

(Au, Kong, Leung, Ng and Pun, 1999)
Appendix B

Consent letter for participation in the Questionnaire Survey

Dear Chemistry Teachers,

My name is Mr. Raymond FONG and I am a student at the University of Technology, Sydney.

I am conducting research into the use of ICT in science education and would like to seek your assistance. The research would involve data collection process using a questionnaire. Your views and comments provided will be recorded anonymously and be used solely for research purpose only. Furthermore, the questionnaires will be destroyed immediately after the research process.

This research has been funded by myself only.

If you are interested in participating, I would be glad if you could complete the attached questionnaire and return it to me by mail. Should you have any query, please contact me or my supervisor Dr. Tony HOLLAND [email: Tony.Holland@uts.edu.au].

You are under no obligation to participate in this research. Thank you in advance for your help!

Yours sincerely,

Mr. Raymond FONG
UTS telephone number: (652) 3699 3436
UTS email address: WeiHung.R.Fong@uts.edu.au
Appendix C

Questionnaire Survey

Teachers' Beliefs about and Practices of Using Information and Communication Technology

Section A:  IT for Teaching and Learning of Chemistry

Directions: Please provide information about your use of IT in teaching and learning of chemistry by blackening the most appropriate box. Respond to each item with respect to chemistry teaching and learning in secondary school in the school year 2004-2005.

<table>
<thead>
<tr>
<th>Frequency / times</th>
<th>Nil</th>
<th>1-2</th>
<th>3-5</th>
<th>6-10</th>
<th>More than 10</th>
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<tr>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Spreadsheet</td>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Presentation</td>
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<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Animation</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Drill and practice</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Tutorials</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Multimedia package</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Simulation</td>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Data-logging system</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Webquest</td>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>ChemSense</td>
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<td>□</td>
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</tr>
<tr>
<td>e-Group</td>
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<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Knowledge forum</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Authorware</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Others (please specify)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Please go to Section B!
Section B: Perceived Usefulness and Ease of Use of IT

Directions: Please indicate the degree to which you agree or disagree with each statement below by blackening the most appropriate box. Respond to each item with respect to chemistry teaching and learning in secondary school.

VL = Very Likely; SL = Somewhat Likely; N = Neither; SU = Somewhat Unlikely; VU = Very Unlikely

1. Perceived Usefulness of IT in Teaching and Learning of Chemistry

<table>
<thead>
<tr>
<th></th>
<th>VL</th>
<th>SL</th>
<th>N</th>
<th>SU</th>
<th>VU</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Using IT in my job would enable me to accomplish tasks more quickly.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>b. Using IT would improve my job performance.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>c. Using IT in my job would increase my productivity.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>d. Using IT would enhance my effectiveness on the job.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>e. Using IT would make it easier to do my job.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>f. I would find IT useful in my job.</td>
<td>[ ]</td>
<td>[ ]</td>
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</tr>
</tbody>
</table>

2. Perceived Ease of Use of IT in Teaching and Learning of Chemistry

<table>
<thead>
<tr>
<th></th>
<th>VL</th>
<th>SL</th>
<th>N</th>
<th>SU</th>
<th>VU</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Learning to operate IT would be easy for me.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>b. I would find it easy to get IT to do what I want it to do.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>c. My interaction with IT would be clear and understandable.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>d. I would find IT to be flexible to interact with.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>e. It would be easy for me to become skillful at using IT.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>f. I would find IT easy to use.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Please go to Section C!
### Section C: Beliefs about Teaching with Technology

**Directions:** Suppose your goal is to effectively use technology in your classroom. Listed below are a number of school environmental support factors that may have an impact on this goal. When responding to the list, please indicate in the first column the degree to which you believe each factor will enable you to effectively use technology. In the second column, indicate the likelihood that these factors will occur (or be available to you). Please blacken the most appropriate box against descriptor that matches your belief.

SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree
VL = Very Likely; SL = Somewhat Likely; N = Neither; SU = Somewhat Unlikely; VU = Very Unlikely

<table>
<thead>
<tr>
<th>Column #1</th>
<th>Column #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The following factors would enable me to be an effective teacher.</td>
<td>How likely is it that these factors will occur in your school?</td>
</tr>
<tr>
<td>SA</td>
<td>A</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1. Resources (funding, equipment, etc.)</td>
<td></td>
</tr>
<tr>
<td>2. Professional development opportunities on using technology</td>
<td></td>
</tr>
<tr>
<td>3. Access to the Internet</td>
<td></td>
</tr>
<tr>
<td>4. Quality software</td>
<td></td>
</tr>
<tr>
<td>5. Physical classroom structures (electrical outlets, movable tables, circuit breakers, space, etc.)</td>
<td></td>
</tr>
<tr>
<td>6. Support from school administrators</td>
<td></td>
</tr>
<tr>
<td>7. Support from parents</td>
<td></td>
</tr>
<tr>
<td>8. Support from other teachers</td>
<td></td>
</tr>
<tr>
<td>9. Technical support (technician)</td>
<td></td>
</tr>
<tr>
<td>10. Time to plan for technology implementation</td>
<td></td>
</tr>
</tbody>
</table>
### Column #1
The following factors would enable me to be an effective teacher.

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Time to let students use technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Smaller class sizes</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>13. Mobile equipment (laptops, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>14. Proper connections (computer to projector, etc.)</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Column #2
How likely is it that these factors will occur in your school?

<table>
<thead>
<tr>
<th>SA</th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SD</th>
<th>VL</th>
<th>SL</th>
<th>N</th>
<th>SU</th>
<th>VU</th>
</tr>
</thead>
</table>

Please go on to the last section!
Section D: Demographic Data

Directions: Please provide information about yourself by blackens the most appropriate box.

<table>
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<th>Descriptor</th>
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<th>Aided</th>
<th>Caput</th>
<th>DSS/Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Type of school:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. School district:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Students' abilities:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Age:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Gender:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Highest qualification in science:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Highest qualification in education:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Teaching Experience (years):</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Position in chemistry department:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Chemistry teaching level:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. Average number of working hours after school per day:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. IT competency level:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. Personal IT use*:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

(* Two or more responses are acceptable.)

Contact Email: ____________________________ (Optional)

That is the end of questionnaire. Thank you for your help!
Appendix D

Consent letter for participation in the Interview

UNIVERSITY OF TECHNOLOGY, SYDNEY
INFORMATION LETTER
EdD Student Research

Teachers' Beliefs About and Practices of Using Information and Communication Technology

Dear Chemistry Teachers,

My name is Mr Raymond FONG and I am a student at the University of Technology, Sydney.

I am conducting research into the use ICT in science education and would like to seek your assistance. The research would involve attending a 2-hour interview session scheduled later this year. Your views and comments provided will be recorded anonymously by writing field notes and be used solely for research purpose only. No video or audio recording will be carried out in the session. Furthermore, field notes gathered will be destroyed immediately after the research process.

This research has been funded by myself only.

If you are interested in participating, I would be glad if you would contact me by sending me an email or by phone. Should you have any query, please contact me or my supervisor Dr Tony HOLLAND (email: Tony.Holland@uts.edu.au).

You are under no obligation to participate in this research. Thank you in advance for your help!

Yours sincerely,

Mr. Raymond FONG
UTS telephone number: (652) 3699 3436
UTS email address: WaiHung.R.Fong@uts.edu.au
Appendix E

UNIVERSITY OF TECHNOLOGY, SYDNEY
EdD Student Research
Interview Questions

1. What do you think about the usefulness of ICT-based tools in teaching and learning of chemistry?

2. Do you think ICT-based tools for teaching and learning of chemistry easy to use?

3. Please describe your experiences of ICT in education gained in study at secondary school, undergraduate and postgraduate levels. Does it affect your practice of teaching? Why and why not?

4. Please describe your experiences of ICT in education gained in courses offered in the ITED project, EDB. Does it affect your practice of teaching? Why and why not?

5. Please describe how people (e.g. fellow teachers, administrators, laboratory technicians, students, parents, etc.) have either helped or hindered the use of ICT in teaching and learning of chemistry.

6. Please describe how the physical environment (e.g. classrooms, laboratories, availability of software, equipment, etc.) have either helped or hindered the use of ICT in teaching and learning of chemistry.

7. How do you deal with challenges and obstacles in the use of ICT in teaching and learning of chemistry outline in questions 5 and 6 above?

8. Please describe a case that you think is an exemplary use of ICT in teaching and learning of chemistry.

9. Please summarize your beliefs about the teaching and learning of chemistry with ICT.

Thank you for your participation.
### Appendix F

**ICT-based tools in chemistry education in Hong Kong secondary schools**

<table>
<thead>
<tr>
<th>Category</th>
<th>Software Tool</th>
<th>Example (Source)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Office automation</strong></td>
<td>Word processing</td>
<td>MS Word <a href="http://www.microsoft.com">http://www.microsoft.com</a></td>
</tr>
<tr>
<td></td>
<td>Spreadsheet</td>
<td>MS Excel <a href="http://www.microsoft.com">http://www.microsoft.com</a></td>
</tr>
<tr>
<td></td>
<td>Presentation</td>
<td>MS Powerpoint <a href="http://www.microsoft.com">http://www.microsoft.com</a></td>
</tr>
<tr>
<td></td>
<td>Drills and practices</td>
<td>Test Construction Support System for Chemistry Teachers (Version 2.0), Chinese University of Hong Kong <a href="http://www3.fed.cuhk.edu.hk/chemistry/">http://www3.fed.cuhk.edu.hk/chemistry/</a></td>
</tr>
<tr>
<td><strong>Process-oriented</strong></td>
<td>Simulation</td>
<td>Equil (v1.0), Shareware on chemical equilibrium created by Timothy J. Allen <a href="http://www.geocities.com/CapeCanaveral/9687/">http://www.geocities.com/CapeCanaveral/9687/</a></td>
</tr>
<tr>
<td></td>
<td>Data-logging system</td>
<td>DataStudio, PASCO Scientific <a href="http://www.pasco.com/software">http://www.pasco.com/software</a> prod/</td>
</tr>
<tr>
<td></td>
<td>Webquest</td>
<td>Hazardous Chemicals in Your Home <a href="http://www.janson.ca/queen's/webquest.htm">http://www.janson.ca/queen's/webquest.htm</a></td>
</tr>
<tr>
<td>Category</td>
<td>Software Tool</td>
<td>Example (Source)</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Constructivist-oriented</td>
<td>ChemSense</td>
<td>ChemSense – Visualizing Chemistry</td>
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<td></td>
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<td>Yahoo Group</td>
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Appendix G

**Education and Manpower Bureau Internal Reference**


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 الحقائق الداخلية لطلبة الثانوي العام 2006-2007

**Education and Manpower Bureau (2006)**

Page A14
Appendix H

General Guidelines for Assessing Science Permitted Teachers

(I) Integrated Science

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(II) Physics/Chemistry/Biology/Human Biology

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Note: There are no restrictions for Qualified Teacher with recognised degree to teach any science subjects.

*(a) A degree in Biochemistry is considered to be equivalent to a degree in Chemistry.

*(b) A recognised Chemistry degree should contain about 30% of Chemistry in the course content.